On Shape and Being Shaped

Rethinking the Urban Built Environment as a Catalyst of Childhood Inactivity and Obesity

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Preface

This thesis is the result of my own work, and includes nothing which is the outcome of work done in collaboration except as declared in the preface and specified in the text. It is not substantially the same as any work that has already been submitted before for any degree or other qualification except as declared in the preface and specified in the text. The work does not exceed the prescribed word limit of 80,000 words for the Degree Committee for the Faculty of Earth Sciences and Geography.

Two peer-reviewed journal articles (Bosch et al. 2019, 2020) have been published prior to the submission of this thesis for examination, based on the multilevel modelling analyses of data from the Size and Lung Function in Children (SLIC) study (Chapter 5, §IV). These articles are attached to this thesis as Appendices 3 and 4. As first author of these articles, I was responsible for the study design, data analysis, interpretation and visualisation, and manuscript drafting. The role of co-authors of these publications was limited to SLIC data curation (Jonathan Wells and Sooky Lum), limited advisory input from my PhD supervisor and advisor (Alice Reid and Jonathan Wells), and manuscript reviewing (all co-authors).

Lander Bosch, October 2020

Abstract: On Shape and Being Shaped - Rethinking the Urban Built Environment as a Catalyst of Childhood Inactivity and Obesity

Lander Sonia Michel Maria Bosch, PhD in Geography, October 2020

Childhood obesity, although a preventable condition, remains a major global public health concern. Despite tremendous efforts, researchers and policymakers have been unable to turn the tide on children's weight gain. In recent years, Health Geographers have increasingly acknowledged the role of place in determining children's levels of extracurricular physical activity, thereby influencing their body shapes. This recognition has not, however, led to a full understanding of the triad connecting the built environment to children's physical activity and body composition. My dissertation therefore aimed to fill this gap by comprehensively uncovering the dynamics at work in this triad. An explanatory sequential mixed-methods research design was adopted, combining the strengths of quantitative spatial epidemiology and the qualitative exploration of children's context-specific lifeworlds in London. The integration of findings obtained through these different research lenses showed that the built environment was severely implicated in determining the body composition of young citizens. This effect, however, was not direct, as out-of-school activity emerged as the crucial pivot mediating the built environmental-body composition relation. Through numbers and narratives, the myriad ways in which the environment, activity and body shape interacted were unveiled. First, I demonstrated the need to disentangle extracurricular physical activity and body mass metrics into their prime components. Having done so, I established that active school travel constitutes a primary pathway in tackling the overweight and obesity epidemic, due to its fat-mass-reducing effect and close associations with the built environment. Integration of quantitative and qualitative evidence showed how proximity to school, traffic safety, the provision of safe and well-maintained pavements and crossroads, and parental perceptions were crucially involved in this relationship. Having contributed to the translation of these findings into policy and practice through concrete policy recommendations, this research constitutes a bold step towards the creation of activity-inciting, leptogenic environments for children.

Acknowledgements

This dissertation is not merely the end product of four years of individual academic research. Above all, it is the reflection of the scientific journey I embarked upon when I arrived to Cambridge in 2016, and during which I had the privilege of collaborating with dedicated scholars from a wide range of disciplines, pivotal to its success. Firstly, I would like to profoundly thank my supervisor, Dr Alice Reid, for her continued guidance and support. From the earliest stages of my study to its final draft, our stimulating discussions were crucial in shaping this work. I am also deeply grateful for the valued advice of Prof Jonathan Wells and Dr Charlotte Lemanski, my thesis advisers, and Dr Sooky Lum, principal investigator of the Wellcome Trust-funded SLIC Study at UCL Great Ormond Street Institute of Child Health (grant number WT094129MA). The financial and academic support for this study from the Economic and Social Research Council (grant number ES/J500033/1) and Gonville & Caius College Cambridge is also truly appreciated. Furthermore, I greatly value the academic and support staff at the Department of Geography, and in particular Dr Alex Jeffrey, Dr Mia Gray, Katrina Purser and the Cambridge Group for the History of Population and Social Structure, for creating a welcoming and inspiring research environment.

A special thank you goes to all the children and families participating in the SLIC study, and especially those from Newham and Brent with whom I travelled some ninety miles across London. It was an honour learning from you as you showed me around your home and school neighbourhoods, enthusiastically sharing your inspirational stories and creating this research together. I profoundly hope this dissertation will contribute to making the neighbourhoods where you grow up places you enjoy and where you feel at home. Having had you as guests at my University and discussing your future plans and dreams, I am confident you will become the doctors, teachers, football players or Cambridge students you aspire to be! I would also like to express my sincere appreciation to the headteachers and staff at participating schools for their selfless facilitation of this work. I am also indebted to the Public Health Departments of Newham and Brent Borough Council, and especially Marie McLoughlin, Sarah Hawken and Cllr Ketan Sheth, who actively supported this study and ensured its translation into policy.

Beyond the world of research, I would like to thank Issy, Adam, Hyesop, Tom and the entire 2017 PhD cohort and my colleagues in HB10 for the friendship, heads-ups about vital emails and innumerable laughs over the years. I'm also grateful to fellow Health Geographers Sarah and Momodou for the countless inspiring discussions and reading group sessions. In Caius, special thanks go to the Director of Studies in Geography Dr Karenjit Clare, Martin, Ivo, Amelia, Nico, Lisa, the Europeans and all those others who patiently listened to lengthy elaborations on the importance of physical activity in driving down childhood obesity rates. Thanks as well to the MCR rowers who bore with my novel approach to rowing and steering. Then there are 'old' friends from my Leuven undergrad and Erasmus Mundus Masters, as well as those 'new' friends I was lucky enough to meet in Cambridge, Kenya and beyond. You were and are very dear to me. Finally, to my parents, Hilde and Peter, and sisters, Barbara and Saskia – thank you. I cannot begin to describe how grateful I am for your invaluable support from across both the Channel and the pond over these years of exploration.

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List of Abbreviations and Acronyms

BAME: Black, Asian and Minority Ethnic

BMI: Body Mass Index

CA: California

CEDAR: Centre for Diet and Activity Research

CI: Confidence Interval

CoL: City of London

FAS: Family Affluence Scale

FEAT: Food Environment Assessment Tool

FFMI: Fat-free Mass Index

FMI: Fat Mass Index

GIS: Geographical Information System

GPS: Global Positioning System

H & F: Hammersmith and Fulham

IMD: Index of Multiple Deprivation

K & C: Kensington and Chelsea

km: kilometre(s)

LSOA: Lower Super Output Area

m: metre(s)

MET: Metabolic Equivalent of Task

MRC: Medical Research Council

MSOA: Middle Super Output Area

MVPA: Moderate-to-Vigorous Physical Activity

N: Number

NHS: National Health Service

OR: Odds Ratio

OS: Ordnance Survey

PE: Physical Education

PM: Particulate Matter

REC: Research Ethics Committee

SLIC: Size and Lung function In Children

UCL: University College London

UK: United Kingdom

UN: United Nations

UNCRC: United Nations' Convention on the Rights of the Child

US(A): United States (of America)

WHO: World Health Organisation

Chapter 1: Introduction – Connecting Children's Built Environments, Extracurricular Physical Activity and Body Composition

> *"Well, the problem is, in this neighbourhood, a lot of children are obese, and the Council comes and asks* 'Can we measure your children?'*, and then they say they're obese. But they don't do anything about it, they just measure. So I hope and pray this research will lead to something for the kids. [...] When you talk about unemployment, how many people can afford their kids to go even swimming? Everything in this country, you need to pay. It's all about money, money, money. Just put a playground and make the kids feel safe. Even with the parents: it would make us come out, sit with the parents, have a chat."*
>
> \- Mother of interviewed child 9 in Newham, East London

Childhood overweight and obesity constitute one of the most grave public health issues of our time. Since the 1980s, rates of excess weight among children have risen sharply in the Global North, with nations in the Global South quickly catching up in recent years (Hu 2008). Worldwide, in the four decades between 1975 and 2016, the number of children aged five to nineteen with a Body Mass Index (BMI) in the obese category has risen over tenfold, from eleven to 124 million (NCD-RisC 2017). In addition, a whopping 213 million children and adolescents were classified as overweight, having a surplus of adipose tissue yet not meeting the obesity threshold (NCD-RisC 2017).

The consequences of excess weight are profound and far-reaching, and include a wide range of both physical and psychosocial comorbidities (Pulgarón 2013). Compared to children with healthy weight, those with overweight or obesity are more likely to suffer from hypertension, metabolic disorders, cardiovascular disease, sleep apnoea and musculoskeletal conditions, alongside lower self-esteem, bullying, and poorer school attendance and performance (Gupta et al. 2012; Pulgarón 2013). Moreover, depending on the degree, duration, and distribution of a child's adiposity, this poorer health is likely to persevere in adulthood (WHO 2020a). The severity of these health impacts could even entail a reversal in the life expectancy gains steadily made throughout the modern era (Daniels 2006).

Beyond the purely biomedical, a large share of individuals with excess weight in a population also has severe direct and indirect economic implications. While the global cost of obesity is near-impossible to calculate, several studies have attempted to account for the financial burden of excess weight at the national level. In Germany, for instance, the lifetime cost of childhood overweight and obesity at current prevalence is estimated at £1.64 billion, or $1.98bn (Sonntag 2017). Moreover, an adult with excess weight and a history of childhood obesity costs healthcare systems and the broader economy up to five times as much as the resources required for an overweight or obese adult with healthy weight during childhood (Sonntag 2017).

Confronted with these severe health and economic implications, it is important to stress that obesity is a preventable condition (Lancet Public Health Editor 2018). This raises the question why this global epidemic has not been curbed in the past four decades, and how it is able to continue to spread and affect an ever-growing share of the global population. A possible answer to this question is provided by the late Geoffrey Rose, prominent professor in epidemiology at the London School of Hygiene and Tropical Medicine. He noted that drivers of population-level changes in disease incidence could be overlooked if there is a sole focus on the causes of individual cases (Rose 1985). Following this line of thought, Rodgers and colleagues (2018) argue that governments and healthcare policymakers have structurally missed the root causes underlying population weight gain, resulting in a lack of agency to undertake the urgently required, bold steps to *"tackl[e] obesity seriously"* (Lancet Public Health Editor 2018, p.e153).

Tackling obesity seriously requires stakeholders to move away from blaming and stigmatising individuals and families through an overreliance on public health messages centred around limiting calorie intake and increasing physical activity (Lancet Public Health Editor 2018). At the same time, a move towards the rethinking of economic and political models that are barely interested in equity or social justice is warranted (Lancet Public Health Editor 2018). In particular, this long overdue process necessitates a radical overhaul of urban environments that can contribute to reducing obesity levels by facilitating and promoting physical activity (Lancet Editor 2017).

This reality represents an inconvenient truth for governments and policymakers. Their striking lack of resolve to take bold steps in the fight against childhood obesity thereby inspired my Health Geographical doctoral research. Heeding the call to tackle obesity seriously, I set out to study the multifarious relations between children's built environments, their opportunities to engage in physical activity, and their body composition. The choice to focus on the energy-expenditure component of the body weight equation, rather than zooming in on calorie intake through food and beverage consumption, has a threefold rationale.

First, physical activity has long been recognised to be the *"best buy in public health because of its manifold benefits [...] and opportunities"* (Morris 1994, p.813). Being the most easily modifiable factor in people's daily lives, physical activity holds the potential to contribute to weight maintenance and loss (Harvard School of Public Health 2020; Wiklund 2016). Secondly, the provision of an activity-inciting, leptogenic built environment is of particular importance for children. Their rapid physical and cognitive development goes hand in hand with higher activity levels and more direct interactions with their surroundings compared to adults, shown to have determining effects in later life (Gascon et al. 2016). Moreover, the benefits of physical activity surpass aspects of physical health and weight maintenance. It has been demonstrated to foster creativity, friendship and the simple joy of movement (Burdette & Whitaker 2005), offering a potential for personal development food doesn't possess. Thirdly, obesity stigma generates new, and amplifies existing, health disparities, and interferes with effective interventions (Puhl & Heuer 2010). A focus on physical activity in the urban built environment in relation to children's body composition and broader wellbeing therefore provides an opportunity to abandon the individualising and stigmatising portrayal of children with excess weight and their caretakers as irresponsible (Flint et al. 2016; Wolfson et al. 2015). Concentrating on the bold, structural action required, the view of fat as a sign of individual physical and moral decay can be discarded (Brown 2014).

It is striking to note the sheer scale and simultaneity with which excess weight skyrocketed in populations in the Global North from the 1970s and 80s onwards. Overweight and obesity affected, and continue to affect, all population subgroups, irrespective of sex, age, ethnic group, socioeconomic status and life experience. It is implausible that, as by miracle, all these individuals had a simultaneous slump in willpower with regard to healthy eating and active lifestyles (Rodgers et al. 2018). Rather, widely distributed factors with mass exposure and short lag times lie at the basis of the observed trends of overweight and obesity (Rodgers et al. 2018). This study therefore aims to unearth the role played by one of these key factors implicated in fostering or hindering children's physical activity: the built environment.

The triad connecting the built environment to physical activity and overweight and obesity remains poorly understood for children (Carroll-Scott et al. 2013). There is little unequivocal evidence on the pathways via which environmental characteristics stimulate, or prohibit, physical activity. Similarly, while the associations between activity and weight reduction are elaborately discussed in literature, the precise mechanisms underlying this inverse relation continue to be insufficiently understood. The presence of a direct link between the built environment and overweight and obesity is even less clear-cut. New methodological designs are therefore needed to move forward in the field.

This PhD research meets this challenge by adopting an explanatory sequential mixed-methods study design, consisting of a comprehensive spatial epidemiological analysis, followed by an in-depth qualitative investigation. The selected study location is London, capital of the United Kingdom. As Britain has the highest obesity rates of all Western European nations, the Chair of the Academy of Medical Royal Colleges branded the country 'the fat man of Europe' (Academy of Medical Royal Colleges 2013). Among children, one out of five at reception age is already confronted with overweight or obesity, a figure rising to well over a third by Year 6, at age ten or eleven (NHS 2017). Rates of excess weight are higher in urban environments, and population groups from minority backgrounds and those living in deprived conditions are affected particularly severely (Baker & Bate 2016).

As the interview excerpt at the start of this chapter illustrates, there is still a governmental tendency to focus on action at the level of the individual in the UK, thereby overlooking, or ignoring, the fundamental causes underlying the obesity epidemic. The government's childhood obesity action plan (HM Government 2016; 2018) primarily targets food intake in the school environment, shown to be an unsuccessful approach if done in isolation (Adab et al. 2018). At the same time, policymakers steer clear of suggesting interventions that would alter the dominant economic models, for fear of negatively affecting the food industry's commercial interests (Lancet Public Health Editor 2018). The government plan also ignores the need to enable physical activity in safe and attractive urban environments (Lancet Editor 2017). This is of particular concern, as only one in five schoolchildren meet the minimum requirements of an hour of daily moderate-to-vigorously intense physical activity (MVPA, NHS 2016). Despite the apparent plateauing of rates of excess weight among some pockets of the population, it is thus no surprise that the answer to the question *"Is the childhood obesity crisis is England over?"* (Hamilton-Shield & Sharp 2015, p.212) is an emphatic 'no'. In London, a prime obesity hotspot in the UK, it is therefore time to take bolder steps towards preventing and tackling childhood overweight and obesity.

Paving the way towards these bolder steps in London, following this introduction, my dissertation opens with a discussion of the core concepts related to the study of the environmental impact on children's activity and body composition in the second chapter. There, the notions of the child and childhood, overweight and obesity, physical activity, and the urban built environment are explored, resulting in a comprehensive overview of the theoretical stance adhered to in this research. The third chapter then engages critically with the current evidence on the dynamics at work in the environment-activity-weight triad. This literature review forms the basis for the fourth chapter, in which this study's methodology is outlined. Starting with the identification of three central research questions, the ways in which existing knowledge gaps and flaws in prior research will be addressed are discussed. Assemblages of methods are developed that will enable to provide an in-depth answer to these central questions. The two chapters following the methodological outline then constitute the key results and discussion chapters, detailing the outcomes of applying these sets of methods. On the one hand, chapter five encompasses a three-stage quantitative spatial epidemiological study, unravelling the associations between the objective built environment and the physical activity and body composition for a representative sample of over 1,800 London primary schoolchildren. On the other, chapter six zooms in on the highly localised, micro-scale lifeworlds of some sixty London children aged seven to eleven through the qualitative thematic analysis of their empowered voices and context-specific lived experiences in situ. Both quantitative and qualitative findings are then integrated in chapter seven, the third and final stage of the explanatory sequential mixed-methods research design. There, a synthesis is provided whereby the spatial epidemiological trends are validated, contrasted or expanded by the situated knowledge generated by the local, context-specific fieldwork in London. Finally, in its concluding eighth chapter, the dissertation summarises how this research indeed aims to *"lead to something for the kids"*, as hoped for – and rightfully expected – by children, parents, carers and the wider population in the UK's capital.

Chapter 2: Theoretical and Conceptual Framework

I. Chapter Introduction

This doctoral research is situated at the intersection of two sub-disciplines within geography: Geographies of Health and Children's Geographies. The analytical focus on the mutually constitutive relationship between health and place, more concretely on the interrelation between the urban built environment, children's physical activity and childhood overweight and obesity, makes the study decidedly Health Geographical (Kearns & Collins 2010). At the same time, it attends to the specific experiences, issues and voices of children and young people. A focus on this group, making up a fifth of the UK population which often remains ignored in Human Geography (Horton et al. 2008, ONS 2019), distinctly frames the research in the field of Children's Geographies. However, the concern for the health and wellbeing of children in this research is not only related to their significant population share or aimed at highlighting their importance for our societies and communities. Studying the experiences of children, youth and their families in Human Geography also enables us to *"enhance [our] understanding of the big questions within the discipline"* (Holloway 2014, p.386).

As both subfields develop, questions arise about the consensus-based mode that guides a large share of work in Geographies of Health and Children's Geographies (Rosenberg 2017; Vanderbeck 2008). Their theoretical frameworks and concepts, and political, methodological and ethical implications, are insufficiently clarified and therefore have increasingly become subject to criticism. The literature review in the next chapter (chapter 3), supporting and guiding this doctoral research, demonstrates that this critique is not ill-founded. The key notions related to the triad of the built environment, physical activity and childhood overweight and obesity employed in this study are not wholly unambiguous. Nonetheless, these notions are frequently used in academic research and policymaking without being soundly framed within a specific theoretical tradition or explicit considerations of the broader implications of selected conceptualisations. In order to address this flaw prior to embarking on the discussion of the research methodology, fieldwork and findings of this study, the core conceptual approaches relied on in this research are presented. For each of the four main concepts – the child and childhood, childhood overweight and obesity, physical activity, and the urban built environment – a brief overview of the key literature is provided, followed by an elaboration of the theoretical stance and conceptual framework I adhere to in this study.

II. Concept 1 of 4 – The Child and Childhood

a. A brief framing of the main conceptualisations in existing literature

Until the 1980s, a developmental paradigm dominated child and childhood studies. Whether from a biological, socio-psychological or educational perspective, children tended to be portrayed as human *becomings* rather than human *beings* (Holloway & Valentine 2000; Barker et al. 2009). According to this reductionist perspective, a child is an inherently immature specimen that biologically and socially has to develop into a mature specimen, the adult. Understanding childhood as a structurally separate stage from adulthood, thereby adhering to Piagetian-style stage theory, explicitly supports a deficit conception of childhood (Matthews 2009), implying that children miss vital characteristics uniquely possessed by grown-ups. Equally, it places children in a disempowered social position (Spyrou 2011). They are denied full access to social rights, are deemed unable to carry adult responsibilities and in need of the constant tutelage of adults such as parents and teachers (Hörschelmann & van Blerk 2012). As a consequence, the latter then have the task of bringing children to full maturity, which involves managing childhood risks, and, more recently, also ensuring a stimulating and enjoyable childhood (Furedi 2008). In this developmental paradigm, the child appears as universal (Barker et al. 2009), and both children and childhood are attributed an ontological status (James 1998).

Emerging in the 1970s as a subfield of Human Geography, Children's Geographies was, in first instance, heavily influenced by this developmental paradigm. At these earliest stages, particular attention was paid to the evolution of children's spatial cognition and mapping abilities (Holloway 2014). The political implication of this theoretical stance is a view of children as powerless, with little agency and no active role to play, even regarding matters that affect them directly. As children are viewed as human becomings unable to fully grasp research, this conception implies that responsible adult 'others', like parents and teachers, can be trusted to speak on behalf of the child, and there is no need to directly engage with children themselves (O'Reilly & Dogra 2017).

From the early 1980s onwards, the renewal of childhood studies driven by feminist and critical theory sought to move beyond this perspective. The perception of children as *"ill-informed incompetents, unable to act responsibly within their communities"* was abandoned, and their independent agency and rights acknowledged and stressed (Matthews 2003, p.4). Key to this new, positive and enabling stance is the idea that children are able to act and make informed decisions unless proven otherwise. This new conceptualisation drove three essential shifts in the academic understanding of 'the child' and 'childhood', which strongly resonated in both Children's Geographies and Geographies of Health.

First, childhood was recognized as a spatially and temporally variable social construct, initially and powerfully illustrated by Philippe Ariès in his 1960 *"L'Enfant et la vie familiale sous l'Ancien Régime"*. This move away from essentialist understandings of the child, defined by chronological-developmental stages, was strengthened by the wider cultural turn in the social sciences. Studies demonstrated how children differ by social categories and experiences of class, gender, ethnicity and physical abilities and inabilities (Matthews 2003, Nairn & Kraftl 2016). These observations drew attention to the inherent power relations and social hierarchies encapsulated in age- and development-based categorisations such as 'childhood' and 'youth', resulting all too often in the structural marginalisation of young citizens (Qvortrup 1994). This inspired both Children's Geographers and Geographers of Health to investigate the social construction of children's spaces and spatialities, as well as the spatial construction of the social realms in which children with a vast diversity of personal characteristics dwell, in relation to their health and wellbeing.

Secondly, the recognition of children's independent agency and autonomous rights fuelled a push towards approaching children and childhoods from an emancipatory perspective. The child became a self-reliant and fully-fledged social being, actor and agent, vital to the creation of her or his own lifeworld (Holloway & Valentine 2000). Breaking the boundaries surrounding children's agency and allowing them to move away from their disempowered social position towards one of rights-based social justice thereby adds a moral imperative to the cause (Spyrou 2011). In consequence, Children's Geographies and Geographies of Health were *"pushed towards something more political"* (Aitken 2018, p.4). This political momentum gained significance, and caused a shift in the international policy discourse on children and childhoods, culminating in the adoption of the United Nations' Convention on the Rights of the Child (UNCRC) in 1989 (UN 1989). Importantly from a Health Geographical perspective, the Convention's signatories commit to providing children with healthy and stimulating environments that allow them to develop to their full potential, free of discrimination and socially protected (UN 1989; UNICEF 2012). The Convention heavily stresses the importance of both the physical and mental health and wellbeing of children in these environments. Article 31 (UN 1989, p.14) specifies the need to guarantee *"appropriate and equal opportunities for cultural, artistic, recreational and leisure activity"* to meet these healthy and stimulating conditions. Whilst this empowering shift was long overdue, Vanderbeck (2008) discusses several drawbacks to a potentially excessive focus on children's independent agency and supposed competence. He argues this might obscure the benefits of limited adult-imposed boundaries to children's health and happiness in specific areas where structural and wider societal issues render children particularly vulnerable – drinking, sexual consent and school-leaving to name but a few.

Thirdly, and finally, one of the core principles propagated by the UNCRC is the respect for and consideration of children's views through freedom of expression and attaching appropriate weight to their opinions (UNICEF 2012), a stance which strongly resonated with international policymaking and academia following the cultural turn. Children were given a place in scientific research, ranging from the requirement to gain their informed assent to their inclusion as active participants, even indispensable (co-)researchers, whose direct voices and first-hand experiences of matters that affect them are crucial (Christensen & Prout 2002; James 2010). Hearing children's voices became pivotal, and their inclusion was often achieved through ethnographic or participatory methods. This prominent place in academic and policy research for children also added *"new complexities and uncertainties to the research process because a new set of factors need consideration"* (O'Reilly & Dogra 2017, p.132). A well-known example is the additional ethical issues that have to be addressed throughout the research process. Despite the incontestable value of recognising the child as independent actor, this strand of work has been open to criticism, centred around two main arguments. On the one hand, the overwhelming emphasis on the micro-geographies of different children, at the expense of a macro-scale analysis, was denounced (Holloway 2014). On the other, scholars acknowledging the adult-imposed limits to the authenticity of children's voices questioned the representation and representativeness of children's voices as fully independent and authentic accounts of their lived experiences (Spyrou 2011; Kraftl 2013).

Today, the traditional developmental perspective on children and childhood has become largely obsolete in Children's Geographies, and Human Geography at large. Nonetheless, this discourse of dependency and a view of children as adults-to-be in need of protection still lingers. The concept of 'stranger danger', for instance, depicts children as vulnerable, running an unacceptable risk in the outdoor public space, and therefore in need of parental restrictions (Murray & Cortés-Morales 2019). In addition, age, and young age in particular – conceived as more than simply a social structure or factor in the production of mobilities – then produces highly politicised mobilities and immobilities throughout children's everyday life, for instance by determining which 'acceptable' routes they can follow (Barker et al. 2009). Despite these remnants of 1970s Children's Geographies, the conceptualisation of children as social actors within their own right has made headway, and its impact continues to be felt broadly to this day (Aitken 2018).

More recently, however, this perception is accompanied by a third conceptualisation of the child as a 'post-child': *"multi-layered, nomadic, relational to human and nonhuman agents, and mediated by technology"* (Aitken 2018, p.17). This image of the post-child is proclaimed by a new wave of scholars aiming to surpass concerns with voice, agency or politics (Kraftl 2013). These scholars argue that a focus on the rights of children and their independent agency is in essence a neoliberal approach, turning children into liberal, rational and isolated subjects. They assert that such a view blurs the dependencies, relations and entanglement of children with other humans and the more-than-human (Kraftl 2013; Boyer & Spinney 2016). Following this third conceptualisation, children and childhoods should therefore be defined as more-than-social and materialized, entangled in the various material artefacts, machines and technologies that surround them (Kraftl 2013; Änggård 2016). The concept of embodiment is closely intertwined with this materiality. Human bodies, too, are deeply interwoven with the material environment, much like voices (Änggård 2016). By consequence, the idea of an authentic, individual voice should be replaced by a more-than-subject voice that is an assemblage stemming from a wide variety of elements (Rautio & Jokinen 2015). The political then has to be re-theorized along the same lines, through the introduction of a shift away from modernist ideas of communicative rationality. Rather than narrowing down the political in relation to children and youngsters to the signifying codes of adult categories such as rational debate and civic engagement, the performative is celebrated (Elwood & Mitchell 2012). The behaviours of children and youngsters – including those considered as voiceless – are defined as the political (Kallio & Hakli 2011).

Methodologically, this so-called performative turn leads to a specific thread of work in Children's Geographies that distances itself from the politically and academically complex terrain of representation (Dirksmeier & Helbrecht 2008). In the case of interviewing, for instance, non-representational researchers are no longer interested in the representations which are produced post-hoc, i.e. the transcript. Indeed, the interview session itself is seen as a performance, and is significant only in the very moment the action is taking place (Dirksmeier & Helbrecht 2008). These non-representational qualitative methodologies in Geographical research are subject to severe criticism. They are claimed to downplay historical or structural analyses, as well as sustained scholarly collaboration, thereby risking *"depoliticizing exactly what many are hoping to make political through their work"* (Mitchell & Elwood 2012, p.801).

b. Theoretical stance and conceptualisation adhered to in this doctoral study

A main driver for my study of the interrelations between the built environments, physical activity and body composition of children stems from the awareness that, all too often, this group remains marginalised in mainstream academic and policy analyses (Holt 2004). There is thus a need to actively document and legitimate their actions, in order to enable children to claim – or, better, reclaim – their rightful space in their multiple environments (Mitchell & Elwood 2012). The point of departure is my view of children as fundamentally embedded in the social, and deeply intertwined with the more-than-social, a view which allows us to abandon the limiting conception of children as separate and isolated, though universal individuals, and to adopt a relational rather than essentialist ontological perspective. Rather than starting the study from the assumption of a pre-existing set of social conditions which constructs everything else, I follow Creswell's (2012) brief but apt description of non-representational theory by recognising that, on the contrary, the all-inclusive materiality produces the social constantly. In essence, this theoretical stance is already reflected in the choice of the research topic of this doctoral study: the reciprocity between the built, *material* environment and children's *unique* body shape and composition, mediated by the *performance* of their physical activity in the public space.

Whilst this perspective is clearly closely aligned with conceptions of the post-child, I maintain that the sea change in the perspective on children as having agency, rights and political lives in the 1980s remains vital today. A valuable extension of this shift is the recognition that there is more to the political in children's lives than purely adult-constructed ideas. Therefore, in the tradition of Bunge, who did not shy away from politics when studying *"Children, [...] the most furious subject"* (Bunge & Bordessa 1975, p.1), this research has clear and outspoken political intentions. The ultimate aim of this PhD is to shed light on the myriad ways in which we, as adults, make and remake the built public space and, by consequence, shape and reshape children's physical activity patterns, body composition and lifeworlds. By placing children at the centre of this discourse, I hope to influence children's politics and to inform and impact adult policymaking. This conceptualisation of the child has the potential to powerfully account for the individual context each child negotiates by explicitly paying attention to age, sex, ethnicity and family and neighbourhood socioeconomic status. However, the limitations of this context-specificity also need to be recognised, as it is not possible to include a separate focus on children with disabilities in this PhD, an area warranting further study (Ross & Buliung 2018).

The importance of listening to children's voices forms the cornerstone of my research methodology. Nonetheless, it should be recognised that participants' narratives have no single origin, and should be understood as *"an ever unfolding multitude of partial voicings"* (Rautio & Jokinen 2015, p.41). However, the challenges of representation subsequently encountered in the process of responsibly and accountably depicting the real-world health and wellbeing issues that arise from children's partial voicings do not at all entail the impossibility of representation. Rather, as Mitchell and Elwood assert (2012, p.792), there is a need to develop new forms of representation, *"ones that blur and refuse old boundary markers and categorizations and which create new alliances and relationships of power".* In first instance, it is thus politically important to articulate the differences between the various children, their narratives and their partial voicings (Holloway 2014). Moreover, defining children as deeply entangled with the social and more-than-social also implies that they are not the only ones capable of producing accounts of their lives. Listening to the voices only of children is not enough, as the objective and subjective conditions of their environments need to be studied. Therefore, Holloway (2014) suggests that we must continue to listen to others who have the power to shape, or are shaped by, children's lives, including parents, educators, policymakers and city planners. Hence, the approach taken in this research rejects the old boundaries and categorizations in Children's Geographies, while unearthing largely unstudied power relations. These relations are closely connected to the various ways that place, health and axes of ethnic and social difference are entangled with and steer children's bodies and activities through structural forces and material practices which need to be fully understood. To expose these relational power dynamics, children thus need to be studied as knowing beings whose lifeworlds are of interest, though at times also as a structural category, providing valuable insights into what groups of adults and children win or lose from the current organisation of society (Holloway 2014).

The aim of gathering and producing these distinct insights into children's locally lived daily experiences, their environments and physical practices has profound methodological implications. Combining statistical data to illustrate patterns and differences between children and their surroundings with detailed, subjective observations of their daily lifeworlds is only possible when using a mixed methods research approach (Johnson et al. 2007). Such *"dialectical discovery"* (Creswell et al. 2011, p.4) requires the integration of data from both quantitative and qualitative methodological angles, and recognizes that knowledge is always partial and situated (Cope & Elwood 2009). The use of this hybrid epistemology is particularly relevant in Health Geographical research, since many research questions in this field, including the ones addressed in this dissertation, involve the investigation of closely interrelated physical-environmental and human processes. An additional advantage of this methodology is its political strength. The distinct and highly varied insights exposed by the combination of research methods are often differentially received by different stakeholders, and this mixture can thus facilitate the understanding of the message by varied audiences (Holloway 2014).

III. Concept 2 of 4 – Overweight and Obesity

a. A brief framing of the main conceptualisations in existing literature

In spite of, or perhaps because of, growing multidisciplinary attention on the issue of overweight and obesity, what it means to be 'overweight' or 'obese' remains heavily debated, especially in relation to the broader notions of health and wellbeing. Taking the various deliberations, scientific traditions and critiques into account, three main understandings of obesity can be distinguished.

Firstly, on one extreme of the definitional spectrum, influential medical institutions like the European Medicines Agency classify obesity as a disease (McGowan 2016), arguing this diagnosis opens up opportunities for better healthcare and insurance coverage for patients. The International Association for the Study of Obesity (IASO 2013) published a strong rebuttal to this approach, countering the overmedicalisation of fatness and highlighting the risks of defining obesity as a disease. The potential stigma experienced by a sizeable population group suffering from excess weight, the classification of people as ill whilst they might feel or be in good health, and the overreliance on often costly drugs and surgery as opposed to the stimulation of essential behavioural change all contribute to the need to reject the medicalisation of obesity.

In contrast, a second body of scholars decentres the medical, claiming that fatness cannot be isolated from the geographical, cultural and historical contexts in which bodies are situated (Evans 2006). This critical approach inspired two strands of research. The first questions the consequences of the stigma around obesity. Stigma is generated when the problem of overweight and obesity is narrowed down to individual families or children, rather than seen as the outcome of complex assemblages of human and material elements that produce fat or slim bodies (Fox et al. 2018). The projection onto the individual has the potential to cause significant harm in different settings, including schools and healthcare services, and risks perpetuating health and social disparities (Graham & Edwards 2013). This observation is supported by studies looking at the embodied experiences of fatness and the highly limited success of individual-centred childhood obesity interventions (Harjunen 2016; McDermott 2018; Weihrauch-Blüher & Wiegand 2018). This first strand of research thereby constitutes an important contributor to the fat activism, fat acceptance and fat pride movements (Gailey 2012).

The second strand then challenges the dominant obesity narrative and the *"regimes of truth"* (Ward et al. 2017, p.257) concerning fatness infused into schools, media and the wider society, and takes two main forms. On the one hand, poststructuralist scholars examine how discursive 'universal truths' around overweight and obesity are produced and reproduced through power relations, benefiting the vested interests of established politics (Monaghan et al. 2013). Central to this discourse is the suggestion that individuals can control, and therefore bear responsibility for, their body shape (Evans 2006). On the other hand, some researchers question the fundamental biomedical understanding and consequences of overweight and obesity. Studies following this line of thought rely on heavily the 'metabolically healthy obesity' hypothesis, for which scholars claim to find evidence in the diversity in type II diabetes risk factors (Phillips 2013). However, mounting evidence convincingly refutes this 'fat-but-fit' narrative. Excess weight has been shown to constitute a strong risk factor for ill-health, independent of external risk factors, current (metabolic) health, socioeconomic status, age, sex and behaviour (Rydén et al. 2016; Lassale et al. 2018). Even for metabolically healthy overweight and obese individuals, the hazard ratios for coronary heart disease are between 25% and 30% higher in comparison to non-overweight peers, independent of any confounders and mediators (Lassale et al. 2018).

Stepping away from the highly limiting definitions of overweight and obesity as either a severely stigmatizing disease or a politically-motivated illusion, the World Health Organization (WHO) offers a third approach to overweight and obesity, considered to be an *"abnormal or excessive fat accumulation that may impair health"* (WHO 2020d, online). Excess fat mass is thus not understood as a disease in itself, but as an important risk factor possibly entailing severe short- and long-term physical and socio-psychological health effects. For instance, based on an extensive review of existing literature, Ayer and colleagues (2015) conclude that sufficient evidence exists to link early-life obesity to adverse changes in cardiovascular structure and function during childhood, resulting in an increased risk of cardiovascular disease throughout the life course. Similarly, breathing disorders during sleep, diabetes and cancer have all been documented in association with obesity during childhood and adolescence (Hamilton-Shield et al. 2014). Beyond purely physical conditions, children with excess weight are also more likely to experience psychosocial issues, which may be further exacerbated by stigma, teasing and bullying (Rankin et al. 2016). Nonetheless, there is no consensus as yet as to whether these psychological problems are caused by or a cause of overweight or obesity, nor whether common factors promote both obesity and psychologic disturbances in children and adolescents who are susceptible to them (Rankin et al. 2016).

In light of this WHO-definition, the question how to measure an *"abnormal or excessive fat accumulation"* is particularly relevant. While the Organisation recognises it is difficult to develop a single, simple index to assess a child's weight status (WHO 2020c), it ascribes the global surge in childhood obesity to two root causes: a global shift in diet towards energy-dense foods, and a trend towards decreased physical activity levels (WHO 2020b). However, to avoid solely blaming individuals and their behaviour, the WHO stresses that the problem is also, and increasingly, related to social and economic development, as well as transport, urban planning, the environment, the food industry and education policies (WHO 2020b). In parallel with the wider dissemination and adoption of this perspective, during the first decade of the 21st century, UK media coverage has seen a significant shift away from a prime focus on individual drivers of, and solutions to, excess adiposity in children, towards articles targeting society-wide factors (Nimegeer et al. 2019).

b. Theoretical stance and conceptualisation adhered to in this doctoral study

In this PhD research, I primarily adhere to the WHO approach to overweight and obesity. Excess fat mass is conceptualised as an important risk factor for ill-health, deeply embedded in the specific cultural context in which the individual with overweight resides, and the outcome of the complex interplay of biomedical, socioeconomic and environmental factors. The insights provided by obesity stigma research and poststructuralist thinking highlight that an adequate theoretical model for overweight and obesity cannot and should not be centred around the individual child and her or his family. Bringing together these considerations, the framework that perhaps best fits this conceptualisation can be found in human ecological approaches to health and disease, such as the model developed by Meade and colleagues for Health Geographical studies (Meade 1977; Meade & Earickson 2000; Meade & Emch 2010). These scholars de-centre the individual by placing the 'state of health' of interest at the centre of a human ecological triangle, enclosed by vertices exploring the habitats, populations and behaviours in which this state of health occurs. Following this tradition, I developed a tripartite model for childhood overweight and obesity, bringing together the work of Harrison and colleagues (2011b) on the developmental ecology of this condition, Pearce and Witten's influential 2010 'Geographies of Obesity', and Hu's 'Obesity Epidemiology' (2008). Their work is supplemented by more recent factors for which more evidence is required, not yet covered in these volumes. It should be noted that several of these factors, such as in-school food programmes and genotypes, fall outside the scope of my doctoral research. Nonetheless, they are argued to play a role in impacting children's weight status. To acknowledge this wide diversity of elements shaping children's bodies and to highlight the complexity of tackling the childhood obesity epidemic, these factors are included in my human ecological model. The components that feed directly into my exploration of the triad connecting children's physical surroundings to their levels of out-of-school physical activity and overweight and obesity are then discussed in-depth in the literature review chapter (chapter 3).

The resulting human ecological model for childhood overweight and obesity can be found in *figure 1*. As in Meade's models, the three reciprocally interacting vertices – habitat, population and behaviour – impact this state of health under study. They surround the condition of excess weight, so no single group of drivers is given more weight than any other, given their highly relative time- and context-dependency. Each vertex is then subdivided in another triangle containing its three main constituents, to which the appropriate factors that have been shown to affect children's weight are allocated. Childhood overweight and obesity are thus presented as a condition resulting from the interaction between biological and behavioural factors, intertwined with the complex structure and nature of the society in which it emerges. The high prevalence of overweight and obesity, in combination with the clear influence of cultural and societal drivers, suggests that structural solutions should play a prominent role in addressing the issue, rather than targeting individual children and their families.

Asking individuals to bear the sole responsibility for the weight status of themselves or their children is unwarranted, and an objectionable negation of our universal societal and political responsibility. Efforts to modify individuals' behaviour must therefore go hand in hand with environmental change, in its broadest sense. A promising strategy in that regard is the focus on children's material environment. Not only does this highlight the interdependencies between children, the human and the more-than-human, it also reveals the society-wide responsibility stemming from the myriad ways bodies and places shape and are shaped by power and politics. In so doing, I focus on the activity aspect of body weight, rather than the food or diet aspect.

In addition to the reasons discussed in the introduction, this choice to target physical activity is driven by the observation that activity-focused interventions have consistently shown to be successful in lowering the obesity risks measured by BMI among school-age children. Diet-based approaches or a combination of both do not show any such effect, recently underpinned by a large-scale Cochrane Review (Brown et al. 2019). Physical activity is thus the key component in childhood obesity prevention and management, and can still be considered *"the best buy in public health"* (Morris 1994, p.813), irrespective of body size, gender, race, ethnicity, or income level (Pandita et al. 2016).

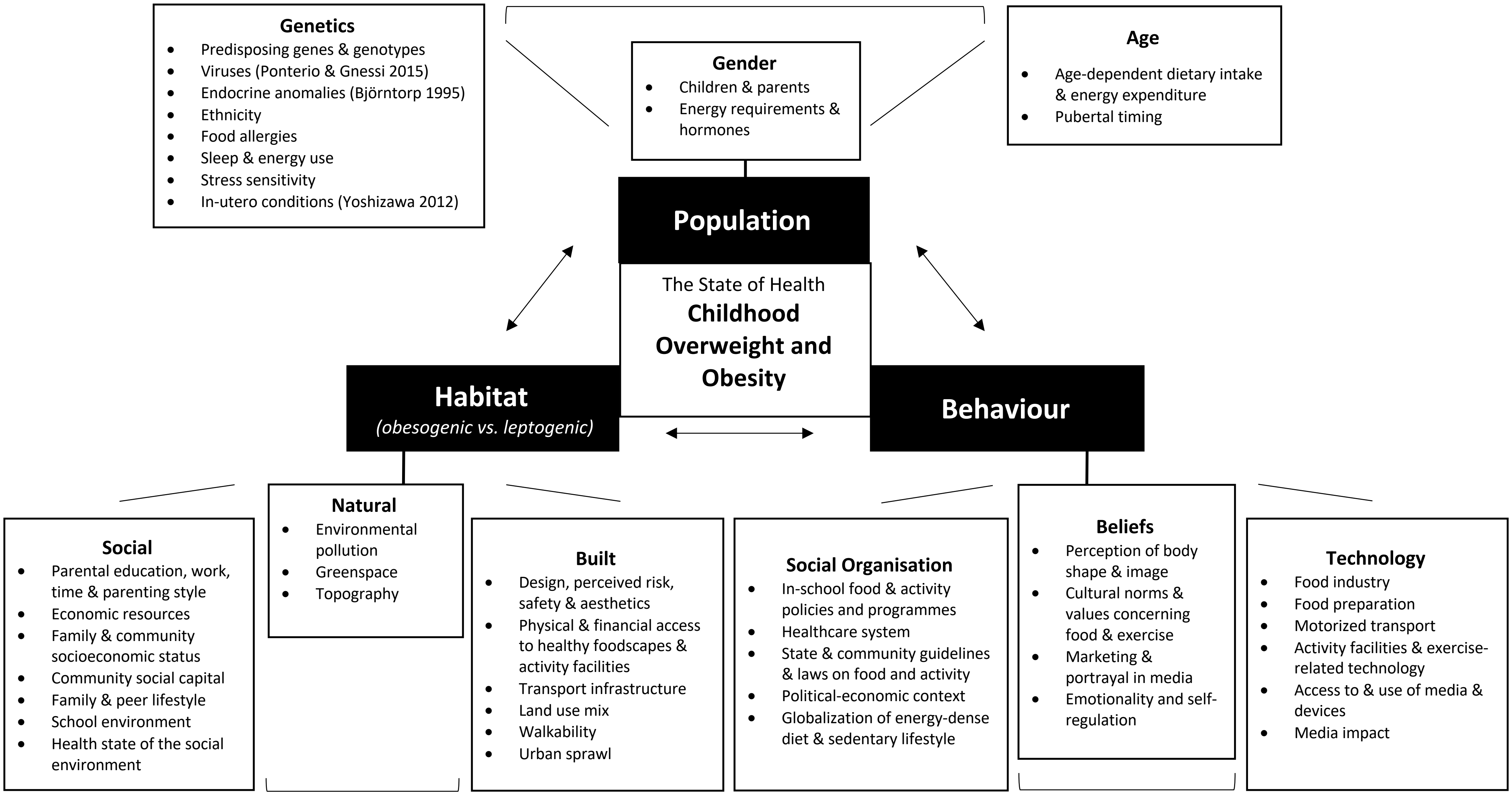


Figure 1: Human Ecological Model for Childhood Overweight and Obesity

IV. Concept 3 of 4 – Physical Activity

a. A brief framing of the main conceptualisations in existing literature

At first glance, physical activity appears to be a fairly straightforward and uncontested concept. Defined by the WHO as *“any bodily movement produced by skeletal muscles that requires energy expenditure”* (WHO 2020e, online), physical activity has been demonstrated to entail strong physical and mental health benefits for school-aged children and youth. As a health-stimulating behaviour, it has been shown to improve cardiorespiratory and muscular fitness, bone health, and cardiovascular and metabolic health biomarkers (Janssen & LeBlanc 2010). A clear dose-response relationship has been established in observational and experimental studies, indicating that higher increases in activity levels are related to greater health benefits. Aerobic activity of at least moderate, and preferably vigorous intensity thus results in substantive health improvements for children of all sizes, and especially those at high risk of obesity (Janssen & LeBlanc 2010). Therefore, the WHO recommends a minimum of one hour of daily moderate-to-vigorous, primarily aerobic physical activity for each child aged five to seventeen, with vigorously intense activities strengthening the musculoskeletal system incorporated at least three times per week (WHO 2020f).

Despite these largely uncontested definition and recommendations, the discussion of physical activity quickly gets more complex when its determinants are studied. There is a growing interest in unravelling these determinants, driven by a rise in public health concerns surrounding the consequences of plummeting physical activity levels around the world (Reis et al. 2016; Katzmarzyk et al. 2015). Similar to what was observed for childhood overweight and obesity, for all too long, physical activity research, policy and practice have been dominated by a focus on theories and models attempting to pinpoint individuals’ psychological and social enablers or inhibitors of exercise and activity (Sallis et al. 2006). This entailed the design of a plethora of interventions targeted at individuals or small groups, yielding modest results at best upon implementation (Giles-Corti et al. 2005).

The limited scope and success of these interventions, narrowly concentrating on psychosocial and behavioural factors, resulted in a push towards an ecological approach, turning attention to environments and populations instead of individuals (Sallis et al. 2006; Abu-Omar et al.

2019). The value of this ecological turn, distinguishing itself from individual-centred approaches through the inclusion of multiscalar environmental and policy-related variables impacting activity choices and opportunities, is supported by empirical evidence (Prior et al. 2014; Yen & Li 2019). The main strength of ecological approaches lies in the recognition of the context-specificity of physical activity, prioritizing the disentanglement of facilitators of, and barriers to, this activity in the place where it is set (Sallis et al. 2006). Studies and interventions rooted in this ecological tradition thus have the potential to increase the levels of physical activity among populations, and are therefore of great importance to public health (Sallis & Owen 2015). This importance is exemplified by support from the WHO for this approach. The Organisation argues for society-wide, culturally relevant efforts to tackle the physical inactivity epidemic that cut across disciplines and sectors (WHO 2020e).

A shift to an ecological perspective also triggers the reconsideration of the concept of 'physical activity' itself for research, policy and practice. As specific sets of individual, social and physical environmental factors and policies are related to specific forms of physical activity taking place in specific settings, the broad concept of *"overall physical activity"* needs to be broken down (Giles-Corti et al. 2005, p.177; Helbich 2017). When unpicking physical activity, many forms can be identified, varying from structured exercise and sports for competition or leisure and physical education, through more unstructured activity modes such as carrying out chores and active commuting, to fully recreational activities set in a family, school or community context.

Given the plethora of heterogenous studies on school interventions for child physical activity and their apparent inadequacy to bring about consistent, sustainable positive change (Adab et al. 2018), out-of-school activity merits further attention. This activity domain, encompassing primarily active commuting and participation in sports and play in the public realm (Drake et al. 2012), resonates strongly with the concept of mobility. The latter notion underwent a strong evolution in recent decades. Since the 1960s, children's mobility research was, and at times still tends to be, placed in a developmental tradition, defining children as highly vulnerable users of the public space in need of perennial protection, a conceptualisation relying on the dichotomy of dependence and independence (Ferenchak & Marshall 2017).

Until the beginning of the 21st Century, this developmental approach was incorporated in predominantly positivist Transport Geography studies (Manderscheid 2016). However, rejecting a dichotomy-based conceptualisation of mobility (Christensen & Cortés-Morales 2016), the 'mobility turn' in social sciences also introduced a new mobilities paradigm in Human Geography (Sheller & Urry 2006). Patterns of transport and travel are now recognized to be interwoven with social relations, experience and materiality, especially for children (Sheller & Urry 2006; Christensen & Cortés-Morales 2016). The notions of interdependency, companionship and collaboration are put forward to stress how children's mobilities are enabled and configured through a diversity of relations and materialities, including the direct physical presence of, or technologically mediated connection with, others (Nansen et al. 2015).

b. Theoretical stance and conceptualisation adhered to in this doctoral study

Following the observations of Giles-Corti and colleagues (2005), the concept of 'overall physical activity' is rejected in this research, as different forms of children's activity take place in different built environments, each with potentially diverging impacts on childhood overweight and obesity. An interest in extracurricular physical activity in the public realm then leads to a focus on children's commuting modes to school and their participation in out-of-school sports and exercise. In relation to children's school commute and wider transportation, I subscribe to the new mobilities paradigm, while also recognizing the strengths of quantitative mobility analyses. As Manderscheid (2016) argues, quantitative analyses are not intrinsically positivist, and quantification can play an important role in critical post-positivist research. The complementarity of quantitative and qualitative elements can substantially contribute to the understanding of how children's mobility-related activity is influenced by the built environment, and impacts their body composition.

In analogy to my approach to childhood overweight and obesity, activity behaviour is studied from a human ecological perspective. Also here, Meade's ecological triangle provides an insightful model to structure the complex set of individual, social and physical environmental factors influencing activity on multiple scales (Meade 1977; Meade & Earickson 2000; Meade & Emch 2010). The resulting human ecological triangle designed for this study can be found in *figure 2*. In this model, the core of the triangle – the state of health investigated – becomes 'children's extracurricular physical activity levels'. An important contribution to the development of vertices in Meade's model is made by Sallis and colleagues (2006). These authors delineate four primary physical activity domains in their 'Ecological Model of Active Living': recreational, transport-related, household and occupational activity. With the exception of the latter, these domains are also applicable to children's out-of-school physical activity. Therefore, they feature in my ecological model, supplemented by a diverse set of established or potential drivers of, and barriers to, children's activity. Once again, this broad and diverse set highlights the multitude of factors determining children's state of health, and several elements fall outside the scope of my research. Those directly relevant to my study are discussed in-depth when reviewing prior literature (chapter 3). It should be noted, however, that this general and introductory tripartite human ecological model might not be exhaustive, as, despite swiftly growing interest in academia, environmental-ecological activity research remains incomplete, particularly for children. Hence, this study also aims to contribute to the clarification of the relative and absolute impact of these vertices, and in particular the habitat vertex, on various types of children's physical activity.

V. Concept 4 of 4 – Urban Built Environment

a. A brief framing of the main conceptualisations in existing literature

The geographical cornerstone of this doctoral study is the notion of the urban built environment, rooted in three other core concepts in Geography: space, place and the city. It is impossible to discuss the urban built environment without also exploring these concepts. All three have undergone a conceptual evolution comparable to the notions of the child and childhood outlined above. Firstly, a positivist interpretation of space subdivides the earth into surfaces and volumes, acting as predictable blank canvasses on which layers of human and non-human action are painted (Nairn & Kraftl 2016). Geographers are then able to map and perform spatial measurements on these Euclidean or geometrically delineated units of space. This raises significant methodological questions, primarily related to the selection of meaningful scales and units of aggregation. Whilst being a powerful illustrative method of portrayal and communication, the analysis of maps can lead to spurious findings if their scale or units of aggregation are ill-conceived (Elliott & Wartenberg 2004).

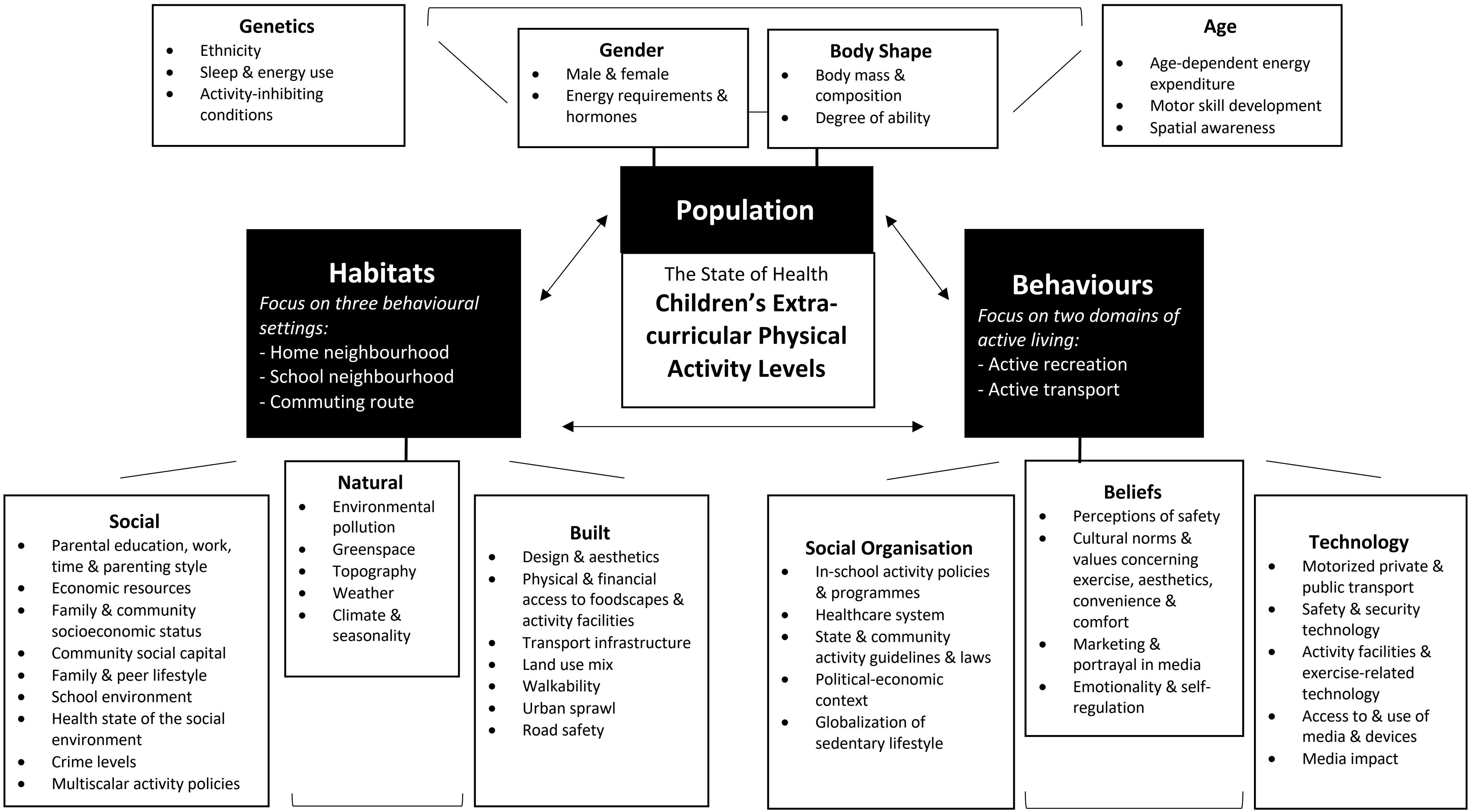


Figure 2: Human Ecological Model for Children's Extracurricular Physical Activity

Inspired by postcolonial and poststructuralist theory, the cultural and critical turn in Human Geography rejected this simplistic conceptualisation of space as a neutral, blank canvas (Couper 2015). Aware of power relations, issues of positionality and sociocultural context-dependency present in these spaces, the concept of place was proposed. Initially defined as a *"meaningful segment of geographical space"* (Creswell 2008, p.134), this basic definition itself became subject to justified criticism. It implicitly makes abstraction of the inextricable entanglement of the spatial and the social – space and place both being concrete, grounded, lived and real (Massey 2005).

To remedy this shortcoming and move beyond the Euclidean logic, the concept of 'spatiality' was introduced (Keith & Pile 1993; Nairn & Kraftl 2016). Massey (2005) adds a dynamic dimension to this concept, demonstrating how it is fundamentally intertwined with time and lived histories (Nairn & Kraftl 2016), both critical to our understanding, development and practising of a sense of place. As the relation between people and place is reciprocal and mutually reinforcing, spatiality is also inherently relational (Amin 2004; Cummins et al. 2007). It should therefore not be conceived as an entity, but as a process consisting of continuous, dynamic and fluid interactions of elements within and beyond itself (Kemp 2011). It is obvious that such fluid and dynamic conceptualisation of space and place entails complexities for methods and methodology (Lees 2003). Researchers engaging with place in any shape or form, and especially those investigating health-related topics, need to account for this relational spatiality (Kemp 2011). They should do so by actively including the spatial, temporal, cultural, social, physical, technological and economic, as well as the multiple ways in which these are experienced and reproduced within both individual and collective structural lives (Kemp 2011). It should therefore not come as a surprise that scholars following this conceptualisation often rely exclusively on qualitative methods, sometimes in combination with mobile data collection technologies.

The concept of the city has undergone a similar evolution to space, place and spatiality. The limits of the positivist interpretation of cities as distinct and clearly bounded urban entities with characteristics that can be readily measured were highlighted by social constructionists in the latter half of the twentieth century (Eade & Mele 2002). Urban political economy theorists also demonstrated that local public policies and, by consequence, social relations, are determined by the reigning political-economic conditions and institutions (Helsley 2008). Both positivist and social constructionist perspectives do not, however, transcend the ontological treatment of the city as a discrete, self-enclosed and analytically separate object that allows economic development and civic communities to thrive (Ward 2010). Moreover, these approaches continue to draw upon a primarily Western interpretation of urban modernity in search of universal accounts of urbanity (Robinson 2013).

Hence, in the early 21st century, driven by ideas stemming from post-colonialism and transnationalism, and grounded in the cultural turn (Eade & Mele 2002), urban studies began to move beyond these notions of internal and external wholeness, and stepped away from a uniquely Western view of the city. A new conceptualisation arose, questioning the territorial integrity of urban environments, and recognising their fluid, porous and relationally connected spatiality (Amin 2004). This highlighted the need for urban studies to include the relationships between and changing nature of areas shaped by urbanisation, including metropolises and countryside, cities and suburbs, and municipalities and regions. The same attention needs to be paid to those residing in, navigating and recreating in urban spaces, as these spaces are experienced differently by each individual actor negotiating them (Gough 2012). People are therefore not simply found 'in' the city, but are also 'of' the city, continuously shaping and being shaped by their surroundings (Skelton & Gough 2013). This new, relational way of thinking therefore concurs with the conceptualisation of the contemporary city as open, discontinuous and internally diverse (Ward 2020). Nonetheless, similar to what could be observed for the notions of the 'child' and 'childhood', myriad definitions of and approaches to the city and citizens remain en vogue in current urban academic thinking and political discourse.

Having addressed the concepts of space, place and the city, it is now possible to unpick the notion of the 'urban built environment'. Commonly defined in Human Geography as *"the human-made space in which people live, work, and recreate on a day-to-day basis, [including] the buildings and spaces we create or modify"* (Roof & Oleru 2008, p.24), these environments are incontestably multifarious and multiscalar. The physical 'buildings and spaces' referred to in this basic definition primarily encompass the infrastructure for all forms of urban land use, including residential and commercial, as well as transportation systems and recreational features (Thornton et al. 2017). The expansion of this concept to also comprise green, blue and therapeutic landscapes and broader notions such as walkability or bikeability is then highly relevant for Health Geographical studies (van den Bosch & Bird 2018).

The acknowledgement of a link between the urban built environment and the body mass of its inhabitants resulted in the emergence of the term 'obesogenic environment' in the 1990s. This spatiality fuels the production and growth of obesity through *"the sum of influences that the surroundings, opportunities, or conditions of life have on promoting obesity in individuals or populations"* (Swinburn et al. 1999, p. 564). There is overwhelming consensus that these material environments are characterised by the high availability, affordability and marketing of energy-dense foodstuffs, while simultaneously constraining physical activity and enabling, even encouraging sedentary activities (Hill et al. 2012). However, this concept is not free of criticism. Building on their questioning of childhood overweight and obesity, Critical Geographers claim that defining obesogenic environments as inducing fatness is short-sighted and problematic, as it implies the onus of maintaining a healthy body shape remains on the individuals who (ir)responsibly interact with these environments (Colls & Evans 2014; O'Hara & Taylor 2018). Irrespective of this criticism, the role of built environments in shaping human health and wellbeing, including obesity, remains a cornerstone of public health, *"empirically confirmed over 150 years of research and today enshrined in social-ecological models and theories"* (Monsivais & Burgoine 2018, p.e4). Therefore, analysing the impact of children's multiple built environments on their body composition and physical activity continues to be vital for the improvement of their physical and mental health.

To study the environment, the 'urban neighbourhood' is often the proposed unit of analysis. Closely linked to space and place, this notion has also seen a considerable conceptual evolution. A positivist perspective relies on bounded administrative entities, such as geometrically delineated wards or local authorities (Feng et al. 2010). However, this internal and external wholeness evaporates quickly and fuzzy geographical boundaries appear as residents define and anchor their neighbourhoods in the local public realm through the presence of and interaction with significant others, landmarks and community dynamics (Young Foundation 2010). Indeed, just like the cities of which they are constituent parts, urban neighbourhoods are inherently open, fluid and relational. The new mobilities paradigm emphasises that nowhere is an island, a statement well-illustrated by the denser or thinner network of connections linking all places, stretching far beyond individual neighbourhoods (Sheller & Urry 2006). This, however, does not mean that movements and mobilities are detached or de-territorialised: they are always located and materialised, and occur through mobilisations of locality and rearrangements of the materiality of places (Sheller & Urry 2006).

b. Theoretical stance and conceptualisation adhered to in this doctoral study

In this PhD study, the urban built environment and neighbourhoods are understood as inextricably intertwined spatialities within which the triad of environmental characteristics, children's physical activity, and childhood overweight and obesity is explored. They are conceptualised as diverse and materialized complex realities, internally and externally relational, and spatially, socially and temporally dynamic.

As this research relies on a mixed-methods methodology, a problem of accounting for the fluidity and porosity of these environments in the quantitative stage of the research arises. Unlike qualitative methods, statistical analyses rely on well-delineated areal units, incompatible with vague and fuzzy boundaries. The issue of integrating quantitative and qualitative paradigms and associated philosophical positions has not been fully clarified to this day (Johnson & Onwuegbuzie 2004). Therefore, in this study, I attempt to capture the changeable, messy and relational nature of urban environments in the quantitative stage to the extent possible by working with small-scale administrative units such as Output Areas and Lower Super Output Areas (LSOAs), and calculating values along children's routes. Whilst not completely solving the issue of relational spatiality, these units can be conceived as building blocks for the variable urban environments and neighbourhoods of children that can be linked and integrated beyond their own boundaries. This problem of identifying built environments and neighbourhoods and recognising their full complexity, fuzziness and relationality disappears in the qualitative stage of the research, where flexible, mobile methodologies can be used. To gain profound insights into the myriad ways the built environment is entangled with children's bodies and physical activity, post-positivist and relational conceptualisations of space are used in complementarity. As highlighted above, such a hybrid conceptual approach has the potential to facilitate the message getting across to varied audiences (Holloway 2014).

When investigating the link between children's surroundings and their body composition, I reject the claim propagated by Critical Geographers like Colls and Evans (2014) that studying the built environment risks reinforcing obesity stigma. In contrast, I believe that not dissecting the built environment would mean to ignore the crucial power of academic work to break down and dismiss the stigmatising discourse around obesity. Following Colls and Evans would imply that scholars working on the built environment should close their eyes to the precise topic they attempt to politicise through their work – in my case, the reclaiming of urban space for and by children, and demonstrating the many ways in which they are intertwined with, shape, and are shaped by their surrounding urban spatialities.

Chapter 3: What We Know – A Literature Review

I. Chapter introduction

The combined epidemics of childhood overweight and obesity and physical inactivity call for a thorough analysis of the built environmental characteristics influencing children's propensity to adopt active lifestyles and how these, in turn, impact their body weight and composition. This chapter therefore aims to illustrate the emerging evidence on the dynamics at work in the triad connecting the built environment, children's physical activity and childhood overweight and obesity, and to highlight where more work is required. This literature review, laying the foundations for the methodological setup of my doctoral study and serving as a point of reference for the interpretation of collected data, consists of five sections. Following this introduction, the second section elaborates on the protocol followed to carry out the selection of relevant literature. The existing evidence on the impact of the built environment on the physical activity and body composition of children is discussed in the third section, following a three-step approach. In the first step, the literature relating the built environment to children's physical activity is presented. The second step then outlines the evidence on the link between the activity levels of children and their weight status. The final step discusses the direct link between the built environment and childhood overweight and obesity described in prior publications. The knowledge gaps and research flaws that can be identified in this existing body of literature which I aim to address through my study are then presented in the fourth section of this chapter, before highlighting the key take-aways from the literature review in the final section.

II. Source selection protocol

The broad aims and scope of this chapter – to provide a qualitative summary of the existing evidence on the dynamics at work in the triad linking the built environment, physical activity and body composition – lend themselves to a traditional, narrative literature review (Brown University Library 2020). However, as I would like to draw evidence-based inferences stemming from the rigorous appraisal of previously published material on this topic and identify remaining lacunae, I opted to adhere to key elements of systematic literature reviews. These include the comprehensive search of a broad range of literature sources, an explicit search strategy, and the reliance on uniformly applied selection criteria for the inclusion and exclusion of sources (Brown University Library 2020; Cook et al. 1997).

To meet these requirements, the literature search was performed using the University of Cambridge's iDiscover online library. Having piloted various combinations of search terms, the body of literature retained for further study was collected by entering the combination of the terms 'built environment', 'childhood overweight and obesity' and 'physical activity'. This set of broad search terms, applied to full text documents, was preferred over more specific notions to avoid excluding relevant literature due to differences in terminology relating to body composition or activity. iDiscover comprises all major academic electronic databases, including PubMed, Medline and Web of Science, as well as references to all print sources available at the University of Cambridge. As research on obesogenic environments is multidisciplinary by nature, this wide range of databases is particularly relevant. The search was restricted to include only work published within the last decade. This well-delineated and recent period was chosen, as both biomedical science and Geographies of Health are rapidly evolving areas of research, and the field of study of the interactions between the built environment and children's health and wellbeing has only grown to full maturity in the early 21st century (Casey et al. 2014).

A classic two-step methodology was applied to retain all relevant materials for the literature review, and to discard sources that did not adequately address the topic under study. First, retrieved sources were culled based on their title, followed by the screening of their abstracts, based on which the final set of literature to be employed was filtered out (Ng et al. 2014). Seven core inclusion criteria were maintained: i) The source is either an academic textbook or peer-reviewed journal article accessible via iDiscover; ii) The source focuses on the relation between components of the triad connecting the built environment, children's physical activity, and weight status; iii) The source focuses uniquely on schoolchildren, or includes a separate section focusing on this topic; iv) The source primarily describes studies set in high-income countries; v) For activity-related literature, the source includes a focus on out-of-school physical activity, either recreational or for transport; vi) Evidence stemming from sources relying on quantitative data is based on a representative population sample or a comparison of population subgroups; and vii) The document is written in English.

The flowchart of this procedure and the number of withheld sources, is shown in *figure 3*. A first search was performed on March 31st, 2017, as part of the literature review for my MPhil dissertation on the same topic, and included articles and books dating back to January 1st, 2008 (Bosch 2017). This initial literature review, on which the present chapter is based, was updated with two additional searches during my PhD: first, on January 31st, 2018, in the framework of my First Year PhD Review Report, and, second, on January 10th, 2020, resulting in the set of 381 sources relied on for the literature review in this dissertation.

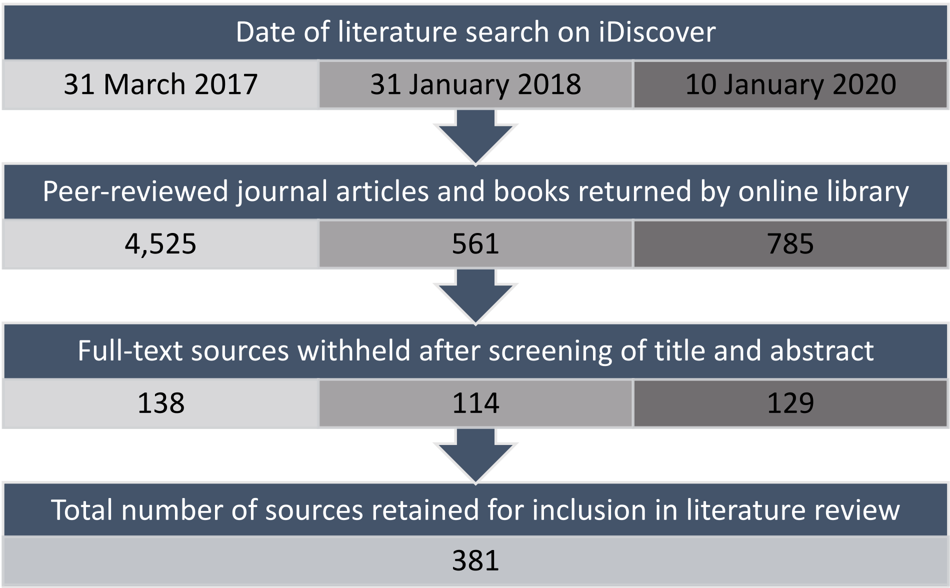


Figure 3: Flowchart for the selection of sources included in my literature review

III. Literature review: evidence on the dynamics at work in the built environment-physical activity-childhood overweight and obesity triad

a. Step 1 of 3: The built environment as facilitator of, or barrier to, children's physical activity

The existence of a link between the physical design of neighbourhoods, including their transportation systems and patterns of land use, and the activity levels of their residents has been widely explored (Durand et al. 2011; Saelens et al. 2014; Wei et al. 2016). The rationale underlying this exploration is straightforward: the characteristics of people's physical environments influence their propensity to choose active transport modes or to recreate or exercise outside, resulting in an increase or decrease in their total physical activity (Gascon et al. 2016). This relation is considered to be particularly important for children, as their higher levels of physical activity in comparison with adults, in combination with their rapid physical development and smaller stature, makes them more sensitive to the multiple environments to which they are exposed (Gascon et al. 2016).

Two main sources of children's physical activity in the outdoor built environment are identified in literature: transport-related activity on the one hand, primarily gathered through walking and cycling, and active leisure and recreation on the other (Bauman et al. 2012; Faulkner et al. 2009). Both forms often occur simultaneously and entail higher levels of physical activity of moderate-to-vigorous intensity throughout the day (Wilkie et al. 2018a). Over the past decade, a plethora of scholars has embarked on primarily quantitative research in quest of objective associations between characteristics of the built environment and children's activity in this environment. However, while neighbourhood characteristics have been shown to be more influential in determining child activity than interpersonal and societal elements, the findings of these studies around the impact of specific built environmental elements remain largely equivocal (de Vet et al. 2011; McGrath et al. 2015; Wilkie et al. 2018b).

The strongest, most consistent associations are found for the first main source of children's outdoor, extracurricular physical activity in the built environment: active transport (Timperio et al. 2015). Proximity is the prime characteristic universally and positively influencing children's choice of active modes of transport, especially in relation to the school commute (Garnham-Lee et al. 2016; Larsen et al. 2012; Remmers et al. 2019; Rothman et al. 2018; Timperio et al. 2015). In both a European and North American setting, the limits of active commuting to school for children have been demonstrated to be about 1.5km for walking, and twice that distance for cycling (D'Haese et al. 2011; Faulkner et al. 2013). As distance to school increases, the number of active commuters drops, while commuting by car grows. Within the boundaries of active commuting, the provision of safe, well-connected routes and infrastructure incites active commuting to school and other destinations which, in turns, entails higher levels of physical activity throughout the day (Carlin et al. 2017; Giles-Corti et al. 2011; Lee et al. 2017; Panter et al. 2008; Rosenberg et al. 2009; Salway et al. 2019).

In an attempt to capture the joint impact of built environmental characteristics on an individual's propensity to use active modes of transport, the concept of 'walkability' has been introduced (Townshend & Lake 2017). Although walking is but one aspect of active commuting, conventionally, the extent to which a neighbourhood is leptogenic through its energy expenditure-inciting characteristics is represented by a composite 'Walkability Index'. Such index is usually composed of three core components deemed fundamental to incite the people residing and moving around the built environment to opt for active modes of transport: land use mix, street connectivity and residential density (D'Haese et al. 2012; Stockton et al. 2016). First, a higher land use mix implies that a variety of destinations is, on average, closer to the place of residence, making the choice for active modes of transport over passive means more attractive (Stockton et al. 2016). This effect is also at play beyond the home neighbourhood: destinations in the vicinity of schools can have similar positive impacts on the physical activity of pupils (Hager et al. 2013). The unvaried land use mix characterising areas with high levels of urban sprawl is therefore particularly problematic (Congdon 2019; Van Hulst et al. 2013). Second, a densely connected street grid makes the urban environment more easily traversable, and can thereby incite physical activity, primarily by stimulating active commuting (Ikeda et al. 2018; van Loon et al. 2014). Finally, the choice to walk and cycle has also been linked to the residential density of the urban space. A high residential density not only implies the necessary critical mass of active road users, but also higher odds of congested passive transport modes, which, in turn, stimulates active transport (Stockton et al. 2016).

While walkability has been shown to be a consistent correlate of adult physical activity around the globe (Althoff et al. 2017), children have received significantly less attention (Stafford & Baldwin 2018). Evidence on the activity-inciting effect of environments with high walkability index scores for children is much more parsimonious (Amram et al. 2020; Gascon et al. 2016; Villanueva et al. 2014; Xue et al. 2020). Even stronger, a high dwelling and intersection density, favourable for adult active commuters, might have the opposite effect on children, deterring them from engaging in outdoor activity (Ikeda et al. 2018; Larsen et al. 2012). More clarification is thus needed to elucidate what comprises walkability for children. Their active transport and outdoor play have been shown to be universally correlated with safe and well-furnished roads, with low traffic volumes and speed and pedestrian and cycling infrastructure (Carver et al. 2008a; Carver et al. 2008b; D'Haese et al. 2015; Timperio et al. 2015; Townshend & Lake 2009). Providing a high-quality transportation environment is thus vital, especially as the activity-deterring effect for children of a lack of adequate and safe road infrastructure is not mediated by potential adult accompaniment (Ghekiere et al. 2016). However, what exactly constitutes a high-quality transportation environment remains to be determined. The limited evidence and heterogenous success levels of active transport interventions demonstrate that the positively influencing activity behaviour remains challenging (Larouche et al. 2018).

Looking at the second main contributor to children's outdoor, out-of-school physical activity, active leisure and recreation, most built environmental variables only show trivial relationships (McGrath et al. 2015). Nonetheless, individual studies returned several significant associations. While evidence is incomplete, the presence, proximity and accessibility of sports and recreational facilities, including playgrounds or green open spaces, appear to entail an increase in children's MVPA (Choo et al. 2017; Congdon 2019; Duncan et al. 2016; Gascon et al. 2016; Kurka et al. 2015; Remmers et al. 2019). These facilities attract children to the outdoors, and have, in various contexts, resulted in their reduced engagement in sedentary activities (Akpinar 2017; Christian et al. 2017; Timperio et al. 2017).

This positive effect is amplified if a wide range of activities is provided, tailored to the diverse needs and wishes of boys and girls of all ages, and set in greenspace (Boonzajer Flaes et al. 2016; Gardsjord et al. 2014; Wheeler et al. 2010). In contrast, a lack of these provisions forces children to be active in more dangerous outdoor environments, exposing them to increased risk of physical harm (Ries et al. 2008). Where the closest outdoor public space is of unsuitable quality, children may still choose to travel further to access more pleasant spaces, though the routes to these spaces often poses considerable obstacles (Timperio et al. 2008). Public facilities are more frequently used and more closely intertwined with children's physical activity levels than their private counterparts, despite the latter being perceived to be of higher quality (Ries et al. 2011). Therefore, it is of the utmost importance that sufficient public space is made available for children's leisure, play and sports engagement, close to their place of residence and safely reachable (Nathan et al. 2018; Sterdt et al. 2014; van Loon et al. 2014). Initiatives such as play streets are particularly promising in that regard (Umstattd Meyer et al. 2019). Significant activity drops have been noted during winter and on cold, cloudy and rainy days (Rahman et al. 2019). Therefore, these spaces should also be weather-proof, to limit the impact of seasonality and day-to-day variations in precipitation and temperature on children's extracurricular physical activity.

Objective associations are, however, not the sole determinants of children's physical activity rates. Subjective experiences of built environments also play a crucial role (Duncan et al. 2012; Garcia-Cervantes et al. 2016; Nathan et al. 2018). Nonetheless, academic studies testing the intuitive expectation that child and adult perceptions of their surroundings influence physical activity decisions have only recently started to deliver consistent findings (Lenhart et al. 2017; Pearce & Witten 2010; Tappe et al. 2013). In particular, parental fears about traffic and crime safety, reigning social norms about responsible parenting and judgements of the child's self-efficacy have decisive weight in determining children's outdoor activity levels, especially in high-fear societies such as the UK (Bennetts et al. 2018; Esteban-Cornejo et al. 2016; Katzmarzyk et al. 2019; Kim et al. 2017; King & Sills-Jones 2018; Loptson et al. 2012; Tappe et al. 2013; Wilkie et al. 2018a). These factors have a particularly strong effect on children's independent mobility (Veitch et al. 2017). Unsurprisingly, kids granted the freedom to play and travel independently show higher levels of physical activity compared to those accompanied by a responsible adult (Schoeppe et al. 2013).

People's perceptions and objective assessments of an environment can differ greatly, in which case the determining power of subjective experiences often prevails (Bringolf-Isler et al. 2018; Prins et al. 2009). Besides a physical issue, accessibility is thus also a psychological variable (Horodyska et al. 2018; King & Sills-Jones 2018; Lake & Townshend 2013), and parental concerns pose a major barrier to the outdoor activity of children (Faulkner et al. 2015). Parents' own activity attitudes and judgements, as role models and gatekeepers, are significant determinants of their offspring's physical activity patterns as well (D'Haese et al. 2013; Rhodes & Lim 2018; Santos et al. 2013; Wilkie et al. 2018a). While the environment might thus appear to be objectively suitable for active transport and play, personal impressions can result in different and seemingly irrational decisions. Children's own accounts illustrate their comfort and discomfort with the social milieus and built environments they negotiate (Loptson et al. 2012; Webb Jamme et al. 2018). Children's independent mobility and active travel to school particularly suffer from negative perceptions (Aarts et al. 2013; D'Haese et al. 2011; Mitra et al. 2013; Panter et al. 2010a; van Kann et al.

2015), lowering overall their activity levels and harming their social and physical wellbeing (Page et al. 2009). A positive, mitigating role could, however, be played by modern technology, as connectivity through mobile devices, such as mobile phones, can reduce parental fears and restrictions (Brockman et al. 2011).

Whilst several broad trends can thus be identified, the set of objective and perceived characteristics determining child physical activity is unique to each socio-spatial setting (Demant Klinker et al. 2015; Pearce & Witten 2010). This context-specificity is rarely recognised, and makes it hard to draw universal conclusions on barriers to, and facilitators of, active transport and recreation. Characteristics can be highly specific and difficult to translate to other settings. For instance, in one place, children are found to be more recreationally active in areas with tree cover (Janssen & Rosu 2015), while in others the presence of peers, siblings or the provision of fixed playground equipment prevails (Kracht & Sisson 2018; Larson et al. 2014). Similarly, there is overall evidence pointing towards children's higher engagement in physical activity in suburban areas relative to urban or rural settings (Collins et al. 2012; Sandercock et al. 2010). However, this trend is not supported in all study locations, once again precluding unequivocal conclusions (Craggs et al. 2011; Donatiello et al. 2013). Other characteristics, such as the impact of air pollution on children's activity, remain structurally understudied (An et al. 2018).

These sources linking the built environment to children's physical activity primarily focus on the habitat and behavioural vertices of the human ecological triangle. Nonetheless, population-level and individual characteristics, more specifically related to children's age, sex, ethnicity and socioeconomic status, can also impact participation in outdoor recreational activities and use of active modes of transport. Looking at age first, the importance of the presence of recreational facilities, greenness and safe infrastructure is particularly pivotal for younger kids, and decreases as children transition to adolescence (Ding et al. 2011). Despite these requirements and stronger parental restrictions to independent activity, younger children still have higher overall activity levels (McGrath et al. 2015; Timperio et al. 2017). This decline in activity with age could potentially be counteracted if road safety were enhanced, as this stimulates the continued use of active transport with increasing age (Carver et al. 2009).

A strong activity gap is also observed between the sexes, widening as children grow older and reach adolescence (Bringolf-Isler et al. 2010). Higher parental restrictions, diverging activity preferences and barriers explain the lower physical activity rates and smaller activity spaces of girls in comparison to boys (Mitchell et al. 2016; Salway et al. 2019; van Loon et al. 2014; Wridt 2010). This results in girls more frequently using passive modes of transport, and a greater need to negotiate their independence collectively (Demant Klinker et al. 2015; Oliver et al. 2011).

In contrast to age and sex, the evidence on the activity variations by ethnicity is still ambiguous (Ding & Gebel 2012; Eyre & Duncan 2013). A key driver of this absence of a consistent relation might be the lack of disentanglement of core activity components. On the one hand, evidence exists which demonstrates that non-whites have higher levels of active transport to school (Oliver et al. 2015; Pont et al. 2009). On the other, children from minority backgrounds have a higher likelihood of belonging to lower socioeconomic status classes. The resulting disadvantaged financial situation and often more deprived and unsafe home neighbourhood may lower their access to play, recreation and sports facilities, negatively affecting their overall activity levels (Galvez et al. 2013; Heidelberger & Smith 2018; Mitchell et al. 2016; Rigolon et al. 2018; Sallis et al. 2012; Taylor 2015; Townshend & Lake 2017).

Socioeconomic status on the family level is also independently related to unhealthy behaviour, beyond the limited ability of less well-off families to afford commercial recreation opportunities (Krist et al. 2017; Ziviani et al. 2008). Children from affluent families are more active than those from less wealthy families, even if they reside in the same neighbourhood, and high socioeconomic status can thus potentially attenuate negative environmental effects and limit the decline in physical activity with age (Clennin et al. 2019; Moore & Littlecott 2015). The important function of parents as role models for and gatekeepers to child activity presents an additional burden here, as this has shown to be weaker for children of low socioeconomic status (Harrington et al. 2017; Seabra et al. 2013). Parental education is key to increased activity levels of children, and low family income is correlated with more time spent engaging in sedentary activities, amplified by children in those families being confronted with more physical activity restrictions and greater access to media (Drenowatz et al. 2010; Tandon et al. 2012). These population characteristics should thus be explored in academic research, and accounted for in policy, as potential determinants, mediators or confounders of children's physical activity in the built environment.

b. Step 2 of 3: Physical activity as a key factor in the fight against childhood overweight and obesity

The limited, inconsistent evidence on the impact of built environmental characteristics on stimulating children's out-of-school physical activity contrasts with the undeniable link established between energy expenditure and the maintenance of a healthy weight status (Pearce & Witten 2010). Continued urbanization, increased chauffeuring and higher levels of sedentary behaviour have led to a significant decrease in child activity levels (Pirgon & Aslan 2015; Sahoo et al. 2015). The human ecological model demonstrated that weight gain is driven by a plethora of interacting variables that need to be further unravelled. Together, these developments have been shown to have contributed to tipping the energy balance towards a surplus of consumed calories over energy expenditure, entailing a sharp increase in overweight and obesity among children (Mitchell et al. 2016; WHO 2020b).

Indeed, using BMI or body fat percentages, countries where children engaged in more MVPA or active transportation had lower rates of obesity among their youngsters, whereas the opposite was found for more sedentary populations (Chaput et al. 2018; Katzmarzyk et al. 2015; Qiao et al. 2017; Stockton et al. 2016). Interestingly, Katzmarzyk and colleagues (2015) established an obesity-controlling threshold of 55 minutes of daily MVPA for their international sample of nine to eleven-year-old children. This closely approximates the WHO guidelines of one hour of daily activity of this intensity. Children with and without excess weight may have similar physical activity preferences, patterns and enjoyment (Deforche et al. 2009; Hong et al. 2016; Larson et al. 2017), however, children with healthy weight are shown to engage in longer, more intense activity bouts (Deforche et al. 2009). Active commuting to school and longer bouts of outdoor, extracurricular MVPA, combined with reduced sedentary behaviour, are therefore key to reducing child weight (Collings et al. 2017; Donatiello et al. 2013; Mitchell et al. 2017; Sarmiento et al. 2015; Tarp et al. 2018). This activity should be sustained year-round, as summer weight gain constitutes an imminent concern for children of primary school age (Tanskey et al. 2018).

Whilst increased activity thus benefits all children, the effect size differs strongly by age, sex, ethnicity and socioeconomic status, calling for tailor-made interventions (Fleary & Freund 2018; Fradkin et al. 2016; Guerrero et al. 2017; Oliveira et al. 2017; Schwartz et al. 2011). The increase in obesity rates among minors has slowed in recent years in high-income countries, though this reduction in the speed at which levels of excess weight grow is significantly smaller among younger children and non-whites (Anderson et al. 2019; Henry et al. 2018). Because of their higher overall activity levels and exposure to the built environment in comparison to older children and girls, younger children and boys are more strongly influenced by differences in physical activity (Fan & Jin 2013; Wolch et al. 2011). This points to the importance of tackling overweight and obesity at a young age, ideally before the age of twelve, as children with excess weight early in the life course are more likely to maintain this unhealthy weight throughout childhood and later life (Braun et al. 2018; Weihrauch-Blüher et al. 2018).

Activity-related health inequalities also unequally affect ethnic minorities through the detrimental impact of their often lower socioeconomic status on activity levels, resulting in a disproportionally high obesity risk among minority groups (Fan & Jin 2013; Townshend & Lake 2017). This risk is amplified by the more sedentary lifestyles of children from low socioeconomic status families (Tandon et al. 2012). It should, moreover, be noted that parents of non-white children in the UK tend to be less concerned about their child's risk of overweight, thereby reducing the odds of action to tackle this issue being undertaken (Firman & Dezateux 2019). Ethnicity and socioeconomic status also show independent associations with weight status. On the one hand, non-whites are more likely to be obese, even when socioeconomic confounders are corrected for (Piontak & Schulman 2018). On the other, children from low socioeconomic status families and neighbourhoods, including in the UK, weigh more and are shorter than children from wealthier families, resulting in significantly higher rates of overweight and obesity among this group as measured by BMI (Bann et al. 2018; Mohammed et al. 2019; Narisco et al. 2019; Ortega Hinojosa et al. 2018).

c. Step 3 of 3: The direct link between the built environment and childhood overweight and obesity

Whilst human-engineered changes to the environment over the past decades have contributed to significant improvements in population health, they have also contributed to create the *"perfect storm"* that is the obesogenic environment (Ravussin & Ryan 2018, p.9). In parallel with the dissemination of the latter concept, the last decade has seen a considerable increase in studies demonstrating a direct relation between built environmental characteristics and children's weight status, mediated through their levels of physical activity (Benzies et al. 2019; Duncan et al. 2012, 2014; Dwicaksono et al. 2018; Mohammed et al. 2017; Nesbit et al. 2014; Tu et al. 2016). It is now widely accepted that the built environment impacts children's activity levels and, in turn, affects rates of childhood overweight and obesity, also in the UK (Lichtveld et al. 2018; Morgan Hughey et al. 2019; Saelens et al. 2018; Schalkwijk et al. 2018; Vargas et al. 2017; WHO 2020b).

This pathway via physical activity is crucial, as high activity levels are thought to attenuate the potentially detrimental impact of deprived neighbourhood conditions on children's weight gain (Nevill et al. 2018). The need to create leptogenic built environments to mitigate current rates of overweight and obesity among children and prevent further increases is thus well-established. The potentially decisive role of environmental perceptions herein is also recognized (Harrison et al. 2011a; Horodyska et al. 2018). However, only rarely has a neighbourhood characteristic been shown to be directly associated with weight gain in children, as was the case for high crime levels in the UK (van der Zwaard et al. 2018). In contrast, evidence for the majority of built environmental variables remains highly generic and context-specific, for instance on the potential effects of walkability or the food environment on children's physical activity and weight, where intervention success is scarce and short-lived (Bahia et al. 2019; DeWeese et al. 2018; Ghenadenik et al. 2018; Hamano et al. 2017; Jia et al. 2019; Lichtveld et al. 2018; Mead et al. 2017; Panter et al. 2018).

Moreover, individual characteristics, ethnicity in particular, and neighbourhood socioeconomic status once again seem to mediate the built environment-weight status relation (Borrell et al. 2016; Sharifi et al. 2016; Yang et al. 2018). The same characteristic may also have diverging, even opposite, effects on the weight status of children of different age, sex, ethnicity and socioeconomic status (Alvarado 2016; Morgan Hughey et al. 2017). The broad trends describing the direct relation between the built environment and childhood overweight and obesity thus require further exploration. Unravelling the myriad population, behavioural and habitat variables that coexist and exert a cumulative effect on the patterns of weight gain and loss of children will be crucial in that undertaking (Nicolaidis 2019).

IV. Knowledge gaps and research flaws emerging from the literature review

a. Gaps in current knowledge on the environment-activity-obesity triad

In the reviewed sources, two core knowledge gaps can be identified that need urgent addressing to move beyond generic, broad trends and enable the design of successful interventions to tackle the childhood inactivity and obesity epidemics. On the one hand, the overwhelming majority of prior studies adopted a strictly quantitative methodology, and focused on adults in North America and Oceania. This implies that the resulting, predominantly positivist evidence base has severe shortcomings. On the other hand, the ongoing deterministic conception of individuals' bodies and their multiple environments remains problematic. Both gaps require further exploration, to ensure the design of my doctoral study correctly accounts for these limitations.

i. Narrow positivist approaches

Four key shortcomings emerge in relation to the first knowledge gap arising from prior literature. Firstly, a blatant lack of the recognition of the context-specificity of associations impedes a full understanding of the triad. Up to two-thirds of studies are set in North America and Oceania. Little is known about the specific dynamics at work elsewhere in the world (Carlin et al. 2017; Congdon 2019), for instance in a UK context where the urban and societal structure strongly differ (Townshend & Lake 2009). Moreover, the observation that conflicting findings are sometimes reported within the same country, as illustrated by the work of Shearer and colleagues (2012) and Simen-Kapeu and colleagues (2010) in Canada, points towards the need to unpick the impact of the built environment on children's physical activity and body composition at the subnational scale. Too little information is available on the micro-level, focusing on urban environments or even individual neighbourhoods (Procter et al. 2008; Salvo et al. 2019). Making simple – or simplistic – inferences across scales and contexts thereby increases the risk of incorrect assumptions and ecological fallacy (Salois 2012).

The second shortcoming arises from the dominant research focus on adults. Indeed, the impact of environmental features on the physical activity and body weight of populations has largely ignored the presence of the child in these environments (Buck et al. 2015b). The lack of a clear association between children's active commuting and walkability outlined above is a prime example in that regard. Scholars increasingly recognise this omission, and have made initial and successful attempts to develop functional 'movability' or 'playability' indices, centred around the neighbourhood factors encouraging or hindering children's active mobility and play (Buck et al. 2015b, 2019; Janssen & Rosu 2015; Timperio et al. 2015). In so doing, the need to disentangle various activity types should be emphasized (Timperio et al. 2017).

Thirdly, the problem of the delineation of spatial units and concepts as the 'neighbourhood', extensively discussed in the conceptual framework (chapter 2), remains unsolved, leaving us with the question whether predefined, administrative or subjective units are to be preferred in research (Charreire et al. 2016). This is particularly relevant as adults and children define neighbourhoods differently, with children attaching more value to social, rather than physical, environmental attributes (Colabianchi et al. 2014). In addition, the dynamic nature of children's movements and the interconnectedness of their spaces and places, involving the constant negotiation and renegotiation of boundaries, is rarely acknowledged (Bourke 2012). The changing nature of route environments should, however, be central to built environmental studies.

The fourth and final shortcoming relates to the reliance on non-causal, cross-sectional statistical models that do not appropriately account for confounders. This leads to the mass-production of highly limited and untranslatable associations that can rarely be replicated (Ding & Gebel 2012). Whilst it is near-impossible to include all potential confounders in environmental statistical analyses, such as the thermal conditions of specific sections of pavements (Kim et al. 2018), key context-dependent variables that are likely to be pivotal determinants of physical activity and weight assessment outcomes, such as ethnicity (Hudda et al. 2017), should be included at all times. Ensuring a sufficiently large sample size then becomes a requirement to enable the observation of potentially significant associations. Moreover, caution needs to be exerted with regard to the potential non-causality and self-selection that characterises cross-sectional studies (Fan & Jin 2013). It is also crucial to explore potential reverse causality at work in the triad. While physical activity has consistently been thought to lower the odds of overweight and obesity, 'couch-potatoes' might in reality simply engage in less exercise – a worrying hypothesis supported by the lower self-reported and accelerometer-determined activity of children with high BMI scores (Al-Nakeeb et al. 2012; Fröberg 2015; Wilkie et al. 2018a).

ii. Deterministic methodologies

The second core knowledge gap stems from the lack of critical studies employing frontier technology or innovative research methods. As stipulated in my conceptual framework (chapter 2), the deterministic conception of human bodies as isolated black boxes that follow predictable cause effect chains needs to be decidedly discarded (Guthman 2012). In contrast, studies should consider the embodied, socio-cultural experiences and agency of children in the multitude of spatialities in which they dwell, until now largely overshadowed by strictly positivist research (Andrews et al. 2012). The richness critical studies could bring to the study of the environmental drivers of, and barriers to, children's activity and adiposity remains underexploited because of the oft-assumed superiority of 'objective' data and statistical associations.

b. Flaws in prior studies on the environment-activity-obesity triad

The inconsistent evidence and identified knowledge gaps can, at least in part, be explained by three major research flaws that arise from the reviewed literature: the use of inadequate metrics for key research variables, the use of a restrictive methodological framework, and the inappropriate conceptualisation and delineation of space and place. Again, each of these flaws should be succinctly explored, to avoid inadvertently reproducing them in my study.

i. Inadequate metrics

The first flaw relates to the inappropriate measures used to quantify the three core concepts in this study: overweight and obesity, physical activity, and the built environment. BMI, whilst being the most widely adopted measure of excess weight, is an inaccurate proxy of child adiposity. It does not distinguish between unhealthy fat and healthy fat-free mass, thus not allowing exact levels of adiposity to be established, and consistently underestimates actual levels of overweight and obesity (Nuttall 2015; Wells et al. 2002). Moreover, age, sex and ethnicity, vital to determining the differential biological and environmental effects of physical activity on the body composition of individual children, are rarely considered, inciting the use of more accurate ways of assessing adiposity (Hudda et al. 2017; Neovius et al. 2004). More precise measures of fatness are available, for instance skinfold thickness or isotope assessments using deuterium oxide. However, these are often far more complex and expensive to collect (Lum et al. 2015b; NOO 2009). Due to these additional costs, the concern for ensuring valid measurements of overweight and obesity is often ignored for the sake of simplicity (Smith & Cummins 2009). The potential bias resulting from this ignorance is not only found for 'objective' measures: with bodies having become, on average, larger over the past decades in high-income countries, people's perception of what a healthy body looks like has shifted towards an underestimation of excess weight (Oldham & Robinson 2016).

Common activity metrics are equally problematic. Researchers often choose between objective accelerometry and subjective self-report questionnaires to assess children's activity levels. Whereas the former depends on arbitrary intensity cut-offs and correct wear, lacking the contextualization of, and breakdown into, the various types of activity a child engages in, the latter is prone to overestimation through recall and reporting bias (Schnurr et al. 2017; Troiano et al. 2008; Verbestel et al. 2015). Moreover, the agreement between both tends to be limited (Sprengeler et al. 2017).

Concerns around the use of predominantly positivist measures for the third pillar of the triad, the built environment, have also been raised. The scales on which child exposure to multiple environments are considered are highly inconsistent and miss the required micro-level detail (Colls & Evans 2014). In addition, little attention is paid to context-dependent or individual characteristics that might mediate observed associations (Dunton et al. 2009). Unsurprisingly, therefore, this entails either highly generic or strongly diverging results.

ii. Inadequate methods

Looking at the second main flaw emerging from prior studies, the methods that are used to study the triad have also been inconsistent, if reported at all, thereby aggravating the use of inadequate metrics (Ding & Gebel 2012). Moreover, the short time span of standard academic studies often rules out the possibility of carrying out longitudinal or interventional studies, forcing scholars to use cross-sectional statistical analyses. The former are ideally suited to observe slow environmental change beyond researchers' control and its impact on children's physical activity and weight status over time, and their results tend to be inconsistent with the outcomes of cross-sectional studies (Wolch et al. 2011; Arteaga et al. 2018). This hinders the emergence of a coherent set of context-specific drivers and the development of theory.

Even if methodologies are described in-depth, the overwhelming majority of research still tends to staunchly adhere to either a quantitative or a qualitative research paradigm. The literature review demonstrates that a solely positivist perspective, using statistics to 'prove' associations, remains the most frequently employed methodological approach, despite its severe limitations highlighted in the conceptual framework. However, over the past decade, driven by feminist and critical theory, the qualitative paradigm has matured and is now being implemented more frequently, relying on perceptions and subjective measures to gain an in-depth understanding of the context-specific reciprocal relationship between the built environment and its inhabitants (Ganter et al. 2016; Gascon et al. 2016). Little work is being performed, however, that values the distinct and complementary insights both can provide in conjunction, through the adoption of a mixed-methods paradigm, allowing the respective weaknesses of uniquely quantitative and qualitative studies to be overcome (Creswell et al. 2011). Nonetheless, the recognition of the joint influence of human and physical processes on the expression of the built environmental impact on children's physical activity and body composition calls for a hybrid epistemology typical of many geographical research questions (Cope & Elwood 2009).

iii. Inadequate conceptualisations

The third and final flaw distinctly present in prior literature relates to one of the key concepts discussed in the conceptual framework (chapter 2): the delineation of space and place. Most publications still conceived place as the neutral backdrop to individuals' rational and independent decisions (Andrews et al. 2012). The relational, dynamic spatialities that, together, constitute the urban built environment remain all too often ignored. Moreover, the reliance on administrative spatial units to define neighbourhoods does not match the personal experiences and boundaries that individuals may attach to their surroundings (Buck et al. 2015a; Colabianchi et al. 2014; Feng et al. 2010).

The spatial level on which built environmental characteristics influence child activity and weight remains, however, to be determined. Jones and colleagues (2010) found little difference in the power of three neighbourhood typologies – administrative units, computer-generated polygons with maximum internal homogeneity, and subjectively delineated areas based on similar community characteristics – to explain variations in children's physical activity. The authors demonstrated that children's activity was more strongly determined by their direct, physical surroundings than by social community aspects, thereby providing an argument to retain administrative boundaries as units of analysis (Jones et al. 2010). To date, however, the issue of the delineation of space and place remains unsolved, implying inconsistent associations will remain common in the study of the impact of the built environment on children's activity and weight status.

V. Key takeaways from the literature review

From the literature review, six built environmental characteristics emerge which, to varying degrees, have been argued to potentially influence children's body mass, either directly or via their effect on physical activity decisions. However, consistent associations are reported for only one of these characteristics: proximity, either to school or to facilities sports and recreation in the public space. While parental and child perceptions of traffic and personal risk are believed to influence activity decisions, any evidence on the effect of objective neighbourhood safety remains inconclusive. Three more built environmental aspects which could influence children's out-of-school activity and body shape – walkability, air pollution and the foodscape – continue to be structurally understudied, and require further analysis. Hence, this set of six elements characterising children's physical surroundings will form the basis of the exploration of the built environment in my study.

When dissecting these built environments, addressing the identified knowledge gaps and research flaws is a critical aspect of my PhD research. Therefore, specific attention will be paid to acknowledging and scrutinising context-specificity on the one hand, and creating a sound and innovative study design and methodology on the other. The former includes a sensitivity to context-specificity both on the level of the individual child, through the exploration of the potentially confounding or mediating role of age, sex, ethnicity and socioeconomic status, as well as on the population level, through the research setting in Europe, allowing international and intercontinental comparisons. Moreover, by breaking down children's body composition and extracurricular physical activity in the built environment into their prime components, the differential influence of a wide variety of environmental characteristics can be explored in the multitude of neighbourhoods boys and girls negotiate, transcending static geographic boundaries. This dynamic exploration can be facilitated by the use of Global Positioning Systems (GPS), Geographical Information Systems (GIS) and accelerometry, technological tools that have become readily available for ecological-environmental and physical activity studies in recent years (Bagot et al. 2018; McCrorie et al. 2014; Zhao et al. 2019).

The second critical aspect for my doctoral research relates to study design. I will use the respective strengths of the quantitative and qualitative methodological paradigms to overcome their individual weaknesses. In particular, theoretically and technologically innovative qualitative methods should be employed to provide insights into results obtained by employing quantitative methods (Oliver et al. 2011). Listening to children's embodied experiences will allow a deeper understanding of the factors driving their observed physical activity patterns (Pawlowski et al. 2018). The quantitative methods should themselves supersede the simplistic statistical modelling focusing on bivariate relations and unique pathways to physical activity and childhood overweight and obesity that characterise the majority of studies until now (Vandewater et al. 2015). Only then, the combined and relative impact of the full set of built environmental characteristics on health-related outcomes can be unravelled.

Chapter 4: Combining Strengths, Reducing Weaknesses – A Mixed-Methods Approach

I. Chapter introduction

The literature review pointed towards the need for innovative, context-sensitive research that will allow holistic insights into the dynamics at work in the triad of the built environment, children's physical activity, and body composition. This methodological chapter therefore outlines the setup of my doctoral study, specifically designed to address the knowledge gaps and research flaws identified in the previous chapter. Following this brief introduction, the second of six sections elaborates on the selected study location: London, the capital of the United Kingdom. Thirdly, the aim of my study and the set of research questions employed to meet this aim are presented. The mixed-methods approach used to formulate an answer to these questions is introduced in the fourth paragraph. Fifth, for all stages of the mixed-methods research, the specific methods for data collection and analysis are delineated. Finally, the concluding remarks emphasise the importance of the methodological and analytical rigour applied in this study before delving into the research findings.

II. Setting the scene: the joint epidemics of childhood inactivity and obesity in London

Since the 1980s, the United Kingdom has steadily built the reputation of being a world leader in terms of childhood overweight and obesity. The English National Child Measurement Programme reveals that, in the 2017/2018 school year, 12.8% of English children at Reception age (four to five years old) were confronted with overweight, having an age- and sex-adjusted BMI score over the 85th percentile. An additional 9.5% had a BMI placing them in the obese category, scoring over the 95th percentile (NHS 2018). From just over one out of five children with excess weight at the start of primary school, these levels of overweight and obesity rose to 14.2% and 20.1% by Year 6 (age ten to eleven) respectively. Hence, upon reaching adolescence, well over a third of English children are overweight, a fifth even being confronted with obesity.

Whilst these overall levels have plateaued in the last decade, there is no indication that rates of excess weight among children will decline in the near future. Moreover, the data also show that specific population groups appear to be more vulnerable than others (NHS 2018). Levels of obesity are highly gendered, as Year 6 obesity levels were found to be just over 4% higher among boys than girls. Ethnicity plays a crucial role, too, with children of minority backgrounds scoring higher on the BMI scale than whites, especially as they grow older – the Chinese-descendent population forming a notable exception to this overall trend. Finally, levels of overweight and obesity are also socioeconomically determined, with children in the most deprived decile of the Index of Multiple Deprivation being more than twice as likely to be obese in comparison to those in the least deprived decile. This dire situation is worsened by the worrying observation that only 20% of English girls and 23% of boys meet the current recommendations of one hour of MVPA (NHS 2016). It is therefore unsurprising that the World Obesity Federation predicts that, by 2030, over 1.3 million UK schoolchildren will be obese, and that the country only has a 39% chance of meeting the WHO target of 'no increased childhood obesity prevalence by 2025' (WOF 2019).

The UK Government is seemingly aware of this pressing issue. Their 2016 strategic plan, 'Childhood Obesity: A Plan for Action', updated and extended in 2018 (HM Government 2016; 2018), is portrayed by government sources as a holistic, ground-breaking initiative, critical to the fight against excess weight among minors. However, when scrutinising these documents, the reasons why the government has been unable to reduce levels of overweight and obesity among its youngest citizens quickly become apparent. The previous and current Conservative UK Governments, under Theresa May (2016-2019) and Boris Johnson (2019-present), largely ignore the multitude of coinciding factors that drive the emergence of the inactivity and obesity epidemics. Instead, they propose fragmented and mainly voluntary actions centred around children's and parents' individual responsibility, crammed into no more than 25 pages of text (Hanson et al. 2017).

This half-hearted commitment to tackling a major public health crisis implies childhood overweight and obesity are likely to remain a primary source of concern nationwide in the foreseeable future. Moreover, the literature review pointed to the inadequacies and inappropriateness to address this issue on the macro-scale, given the high context-specificity of drivers of, and barriers to, children's activity and weight gain. There is thus a need to search for structural solutions at the subnational scale. The highest levels of childhood overweight and obesity are concentrated in the large English cities, particularly London (Baker 2018; Department of Health 2020b). In comparison to other global cities, London has an exceptionally high rate of excess weight among children, even pipping New York to the post, as the latter has seen a decline in childhood obesity not witnessed in the UK capital (Plant 2015). Today, a baffling 21.8% of Reception children are overweight or obese, a figure rising to 37.9% by Year 6 (Department of Health 2020b). These extraordinary levels also have severe economic implications: today, an annual amount of £31 is spent in direct costs per obese child in London, a costs which rises to £611 a year if this child becomes an obese adult. In total, childhood obesity represents an annual direct cost of some £33.3 million to the London authorities (GLA 2011).

These overall averages mask disturbing intra-urban disparities, perhaps best illustrated by the fact that the local authorities with both the highest and the lowest rates of obesity for minors in England are situated in London. On the one extreme, up to 45.6% of children are confronted with excessive adiposity in the Borough of Brent. On the other end of the spectrum, 'only' 23.3% of children are found to be overweight or obese in Richmond-upon-Thames (Baker 2018). Moreover, London is well-represented in the list of most obese local authorities for children, with Barking and Dagenham (2), Westminster (5), Southwark (6), Greenwich (7), Newham (8) and Tower Hamlets (9) all near the top of the table. Much like England, London is at the same time confronted with a second epidemic, that of childhood physical inactivity. Only some 16% of children meet minimum activity requirements, making young Londoners the least active of all English children (Scholes 2016), with only two in five travelling to school actively (GLA 2011).

London combines the presence of over 1.5 million school-aged children with large disparities in childhood activity and overweight levels according to geographic, socioeconomic, ethnic and gender characteristics, and a large ethnic mix, with only 44.9% of the population being white British (GLA 2019; UK Government 2019). This makes the city the ideal place to explore the impact of the built environment on children's physical activity and body composition. Several London Boroughs have designed upstream interventions and school-based support programmes in an attempt to address the crises affecting the city, but these have, unfortunately, not been successful in turning around the activity and weight trends (Plant 2015). This lack of success stems from the limited comprehension of the context-specific dynamics at work in the built environment-physical activity-body composition triad in London.

III. Research aim and questions fitting the topic under study

My doctoral study aims to collect the appropriate data and build the necessary micro-level evidence to identify London-wide and Borough-specific built environmental drivers of, and barriers to, children's physical activity and overweight and obesity. Given the need to address these issues at a young age, the focus of this research will be on primary schoolchildren. A wide range of information is required to establish a sound knowledge base on what influences their activity and adiposity in the city, and to allow the design of effective interventions to tackle both epidemics simultaneously.

As extensively discussed in the conceptual framework, and supported by the reviewed literature and identified methodological flaws, neither a quantitative nor a qualitative research paradigm is capable of appropriately capturing these drivers of the inactivity and obesity epidemics in isolation. Objectively observed trends thus need to be combined with subjective insights into children's daily spatial practices in, and perceptions of, their urban environments. The inherently different nature of both paradigms calls for two separate central research questions – one quantitative, one qualitative – forming the point of departure for my research (Ivankova et al. 2006). However, no single method, positivist nor interpretivist, can answer both questions. Therefore, a mixed-methods approach needs to be employed. This third methodological research paradigm requires the integration of the quantitatively and qualitatively collected data through a third, hybrid research question (Tashakkori & Creswell 2007). These resulting central research questions guiding this study therefore are the following:

1. Central quantitative research question:

"Controlling for potential confounders, are rates of childhood overweight and obesity in London primary schoolchildren spatially and statistically associated with a predefined set of built environmental characteristics, selected based on an extensive literature review, that foster or hinder their extracurricular physical activity?"

The literature review demonstrated the value of breaking this overarching question down into its composite steps. The first step addresses the relation between the built environment and extracurricular physical activity, whereas the second looks at the link between this physical activity and childhood overweight and obesity. Finally, the direct associations between the built environment and children's weight status need to be explored. Three sub-questions can thus be formulated as follows:

a. From the built environment to children's extracurricular physical activity: *"Controlling for potential confounders, which built environmental characteristics stimulate or counteract the extracurricular physical activity of London primary schoolchildren, starting from a predefined set of elements based on the extensive literature review?"*
b. From children's extracurricular physical activity to childhood overweight and obesity: *"Controlling for potential confounders, is the weight status of London primary schoolchildren related to their levels of extracurricular physical activity?"*
c. From the built environment to childhood overweight and obesity: *"Controlling for potential confounders, which built environmental characteristics are directly related to the weight status of London primary schoolchildren, starting from a predefined set of elements based on the extensive literature review and controlling for extracurricular physical activity?"*

2. Central qualitative research question:

"How do London primary schoolchildren, with and without overweight or obesity, experience and use characteristics of their built environment from an energy-expenditure perspective?"

3. Central integrative research question:

"How do the qualitative findings compare and relate to the quantitative results and help to interpret them?"

IV. Study design: an explanatory sequential mixed-methods approach

Combining complementary Cartesian-positivist and phenomenological, social constructionist epistemologies in mixed-methods research has significantly gained popularity in the last decade, and is used to address broad questions in health research driven by a complex set of factors (Yardley & Bishop 2015). The search for areas of overlap and incongruity to achieve knowledge expansion concerning multifarious issues such as the inactivity and obesity epidemics can be achieved through the thorough study of multiple diverging aspects of the question at hand, followed by the triangulation of their outcomes (Tariq & Woodman 2013). This opens up opportunities for profound data mining by combining the datasets generated by the quantitative and qualitative research questions (Creswell 2016), which can then be combined in a final, separate integrative stage. This intellectual and practical synthesis rooted in both qualitative and quantitative research (Johnson et al. 2007) is thus ideally suited to explore the combination of objective observations of the built environmental impact on children's physical activity and body composition, and the insights gained from children's own narratives concerning their lived experiences in these environments.

In practice, various mixed-methods research configurations have been developed. The choice of a specific design usually depends on the selected theoretical framework, the timing of the quantitative and qualitative data collection, the weight attached to both paradigms, and the mode of data integration (Creswell et al. 2011). Given the purpose of my study to use the qualitative stage to extend the quantitative findings and provide an in-depth understanding of the mechanisms underlying the objectively observed processes at work, an 'Explanatory Sequential Design' is selected (*figure 4*, Creswell et al. 2011; Schoonenboom & Burke Johnson 2017). Conventionally, this design is selected in fields with a strong quantitative orientation, as is the case in research on the impact of the built environment on children's health and wellbeing (Creswell & Creswell 2017). The theoretical underpinnings of this design tend to attach more weight to the quantitative findings and require the subjects studied in both stages to be the same (Creswell & Creswell 2017). These characteristics are slightly modified to fit the specific purpose, context and limitations of this study, in which it is not possible to include the same children in both stages and which views both stages as pivotal and equally valuable to reach a full understanding of the dynamics at work in the triad.

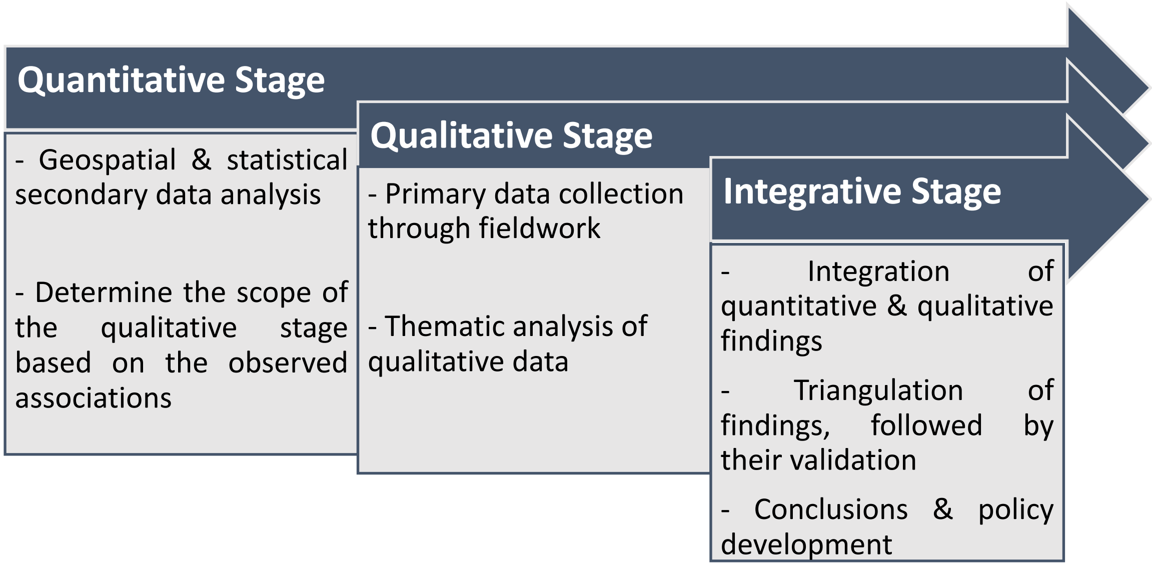


Figure 4: Explanatory sequential mixed-methods design adopted in this doctoral study (Creswell et al. 2011)

V. Quantitative and qualitative methods and analyses employed

a. Stage 1 of 3: Quantitative Spatial Epidemiology

The first stage of the explanatory sequential mixed-methods design is a cross-sectional, spatial epidemiological study, aiming to delineate objective associations between built environmental characteristics, child activity and body composition, in order to answer the central quantitative research question and related sub-questions as outlined above. This section consists of three major parts: a description of the sample used for the quantitative study, an introduction of the selected variables and their operationalization, and a discussion of the methods used for data analysis.

i. Sample

The cross-sectional analyses use data from a sample of London primary schoolchildren who participated in the Size and Lung function In Children (SLIC) study, carried out at the Great Ormond Street Institute of Child Health at University College London (UCL), UK. Between December 2010 and June 2013, an all-encompassing set of data on body composition, health status, physical activity and socioeconomic status was collected for 2,171 children aged five to eleven years, attending thirteen schools across Greater London (Lum et al. 2015a;b). These schools were purposefully sampled based on their diverse geographical location in Inner and Outer London, and varying education performance. Moreover, schools were selected to have strongly diverging ethnic compositions. Together, this ensured the collection of a SLIC sample with a broad spectrum of ethnic and socioeconomic backgrounds, representative of the multi-ethnic population of primary schoolchildren in inner-city environments in the UK, including London (Lum et al. 2015a), expanding the external validity of the research findings to similar settings.

Ethical approval for the SLIC study was obtained from the London-Hampstead Research Ethics Committee (REC: 10/H0720/53). Parental written consent and child verbal assent were obtained prior to assessments for all participants to the SLIC study. Approval for secondary data analyses in this doctoral study is obtained from the REC at the Department of Geography, University of Cambridge, UK (Ethics Assessment Number 698).

ii. Variable definition and operationalisation

The pathway to meaningful and sound quantitative findings starts with the adequate definition of key variables. The literature review pointed out that childhood overweight and obesity, physical activity and the built environment all have been poorly conceptualised and operationalised in prior research, leading to the plethora of contradictory or null-findings. Moreover, the context-specificity of associations has been frequently overlooked through the omission or limited consideration of potential confounders and mediators. Aware of these major flaws, I aim to address these pitfalls by designing appropriate variables to study the triad, and to pay particular attention to individual, family and neighbourhood characteristics.

Childhood Overweight and Obesity

For the operationalisation of childhood overweight and obesity in the quantitative stage, the distinction between fat and fat-free mass is vital, as their health effects vastly differ. Excess fat mass is a major risk factor for physical and socio-psychological health conditions (Sahoo et al. 2015). In contrast, fat-free mass is predominantly composed of muscle mass, which has a strongly positive health impact (Wells et al. 2002). BMI obscures this distinction, and therefore is believed to have highly limited validity (Nuttall 2015). Nonetheless, London-wide measurements of children's fat and fat-free mass are lacking. For the time period during which the SLIC study was carried out, only percentages of overweight and obesity for Reception and Year 6 schoolchildren were available on the Middle Super Output Area (MSOA) level, administrative units with an average of some 8,300 inhabitants in London, using BMI as the measure of excess weight (GLA 2014b; Public Health England 2020).

To operationalise body composition in this study, I relied on the anthropometric information available for the SLIC children, measured directly by the research team at UCL during their visits to schools. This information includes the child's height in centimetres, total body mass in kilograms, and fat-free body mass in kilograms estimated from bio-electrical impedance analysis using standard instrumentation (Tanita BC418, Tanita Corporation, UK). The fat-free mass was calculated from raw bio-electrical impedance analysis using the multi-ethnic calibration equation of Lee et al. (2014), generated from the same SLIC population using deuterium dilution as the reference method. Fat mass, in kilograms, is then calculated by subtracting the fat-free mass from total body mass.

I calculated BMI for SLIC children by dividing their total body mass in kilograms by the square of their height in metres, and converted these raw BMI scores to age- and sex-specific percentiles using the 2007 World Health Organization BMI reference charts (de Onis et al. 2007). Analogous to the calculation of BMI, I divided the fat-free mass and fat mass of SLIC children by the square of height in metres to give Fat-Free Mass Index (FFMI) and Fat Mass Index (FMI) scores. The need for age- and sex-adjusted FMI and FFMI reference charts, similar to those for BMI, has been highlighted in prior research, and these have been developed for specific groups of children (Kim et al. 2016; Nakao & Komiya 2003; Weber et al. 2013; Wells et al. 2014). However, no adequate reference charts currently exist for the age group and ethnic mix of my sample of UK participants. Hence, I converted the raw FMI and FFMI scores to within-study age- and sex-specific z-scores using multiple regression analysis. Age- and sex-adjusted z-scores and percentiles of FMI and FFMI are thus sample-specific, though they can be considered to be representative for the London-wide population of primary schoolchildren aged 5-11, given the large diversity in terms of age, sex and ethnicity of included participants (Lum et al. 2015a;b). To address skew, fat mass was first natural log-transformed.

Following the guidelines of the Centers for Disease Control and Prevention (2018), the 5th, 85th and 95th percentiles were used as class boundaries to assign each individual child in the SLIC database to one of four categories of age- and sex-adjusted BMI (underweight, normal weight, overweight or obese). In analogy, age- and sex-adjusted FMI and FFMI of SLIC children were also subdivided into four categories, designed to be equivalent to the categories for BMI (low, normal, moderate or elevated fat and fat-free mass for height, respectively). Hence, for both FMI and FFMI measures, the 5th, 85th and 95th percentiles were selected as class boundaries as well, as can be seen in *figure 5*.

Age- and sex-adjusted body composition classification for SLIC children			
Percentile	**BMI**	**FMI**	**FFMI**
<5th percentile	Underweight	Low fat mass	Low fat-free mass
5th-85th percentile	Healthy weight	Healthy fat mass	Normal fat-free mass
85th-95th percentile	Overweight	Elevated fat mass	Elevated fat-free mass
>95th percentile	Obese	High fat mass	High fat-free mass

Figure 5: Body composition classifications following Centers for Disease Control and Prevention guidelines (2018)

Physical Activity

Similar to the need to disentangle body composition, the importance of breaking down 'overall' physical activity into its core components strongly emerged from the literature review, where the differential built environmental impact on various activity types was highlighted. Data on two key components of SLIC children's extracurricular physical activity (Drake et al. 2012) were also directly collected during the school visits via a questionnaire: their mode of commuting to school, and their participation in sports and exercise.

Firstly, children were asked for the dominant mode of transport when commuting from home to school. Afterwards, parents and guardians were asked the same question through a parental questionnaire. I classified responses as 'active commuting' if the child predominantly walked or cycled, or 'passive commuting' where car, bus or metropolitan railway ('London Underground' or 'Overground') were the dominant modes of transport. If both active and passive transport constituted significant parts of the commute, this was labelled 'mixed commuting'. Where parent and child responses differed, this was retained by their inclusion in a 'disagreement' category.

Secondly, participants' frequency of participation in a series of twelve sports was gauged. These included the potentially low-cost activities of running and cycling, regular outdoor activities (football, cricket and skating or rollerblading), regular indoor activities (gymnastics, swimming, badminton or tennis, basketball, dancing, judo or boxing, and weightlifting) and an 'other' category where less common sports could be indicated. Possible frequencies ranged from 'never' through 'less than weekly', 'weekly' and 'most days' to 'daily'. A composite measure was constructed, providing an overview of the overall sports participation of each child. It should be stressed that these frequencies rely on self-reported data. While objective measures of physical activity tend to be preferable, the large-scale collection of such data presents major logistical challenges (Monyeki et al. 2018). The wealth of SLIC data and the classification of children's activity frequencies in broad groups is deemed to attenuate the limitations of using subjective measures in my study, although the possible mismatch with objectively measured levels of activity should be acknowledged (Monyeki et al. 2018).

This detailed information gathered by the SLIC team again strongly contrasts with the very limited information available about the London-wide extracurricular physical activity of children, especially for the period of data collection (2010-2013). This complicates a more universal framing of the activity of SLIC children within the broader activity context of London primary schoolchildren. The Department for Education (2014) published only one publicly available, activity-related variable that specifically focuses on children in the relevant time period: the share of pupils engaging in over two hours of weekly physical education (PE) and sports at the borough level, though it should be recognized that this measure focuses in part on within-school physical activity. Moreover, these data were only available at the macro-scale level of the 32 Boroughs, or local authorities, that make up Greater London, with an average population of around 255,000 inhabitants at the time of the 2011 population census (GLA 2011).

The Built Environment

Having discussed the measures of children's body composition and physical activity, the potential drivers of, and barriers to, the levels of both dependent variables need to be defined equally soundly. The literature review demonstrated that six objectively measurable built environmental variables have been suggested to influence children's activity choices and body composition, or require further clarification: proximity to school and to potential recreation facilities, traffic risk, personal risk, air pollution, walkability, and the foodscape. Each of these is therefore included in my quantitative analyses. Raw data on these variables have been collected from various sources, and prepared for analysis through calculations in ArcMap 10.5.1 (ESRI 2017, Redlands, CA, USA).

As underlined in the conceptual framework, tackling the issue of relational spatiality remains problematic in quantitative spatial epidemiological studies. The review of prior research showed that no single, widely applicable solution exists to capture the messy conceptualisation of boundaries and neighbourhoods. Hence, in this study, I chose to examine the impact of the included built environmental variables using small-scale administrative units such as Output Areas and Lower Super Output Areas (LSOAs), and, where possible, to calculate values along the route to facilities. Output Areas are the smallest spatial units meeting the confidentiality threshold, containing a minimum of 40 households, for which UK census data are available (ONS 2012). LSOAs, comprising between 400 and 1,200 households, are aggregations of these Output Areas – small, socially homogeneous spatial units of similar population size – that balance the detail provided by smaller spatial units with the more reliable results for larger, more populated areas (ONS 2016). These units can then be construed as the building blocks for the multiple, changeable environments SLIC children navigate and negotiate.

The first of the six objective built environmental variables included in the quantitative spatial epidemiological study, proximity to school and recreational facilities, has been most consistently associated with stimulating children's active commuting and outdoor recreation. It could thereby have a significant positive effect on reducing levels of excess weight. The location of SLIC children's home, obtained through the parental questionnaire, was included as the centroid of their 2011 Output Area of residence. With 95% of Output Areas containing between 79 and 189 households (ONS 2012), their centroids can be assumed to reasonably approximate the actual location of SLIC children's homes. The location of included schools was provided in the SLIC database, whereas data on sports facilities, parks and public gardens – facilities able to attract children to the outdoors – were made available for my study upon request by the Greenspace Information for Greater London Institute (*figure 6*). For each SLIC child, the sports facility and park or garden closest to home was identified using the 'Near' geoprocessing tool in ArcMap (Wilson & Din 2017).

Using these data, the impact of proximity on a child's propensity to choose an active commuting mode or to engage in out-of-school recreational activity could be assessed, which, in turn, could impact body composition. To that end, the distance to school, to the nearest sports facility and to the nearest park or garden was calculated along the shortest route (in metres) between a participant's home centroid and that of the facility in question, assuming children are most likely to opt for this path. Commuting distances were subdivided into four categories: <500.0m, 500.0m-999.9m, 1,000.0m-1,499.9m, and ≥1,500.0m. The lower boundary of this final category was selected as the literature review showed that 1,500m, or 0.93 miles, is often considered to be the maximum walkable distance for children (D'Haese et al. 2011).

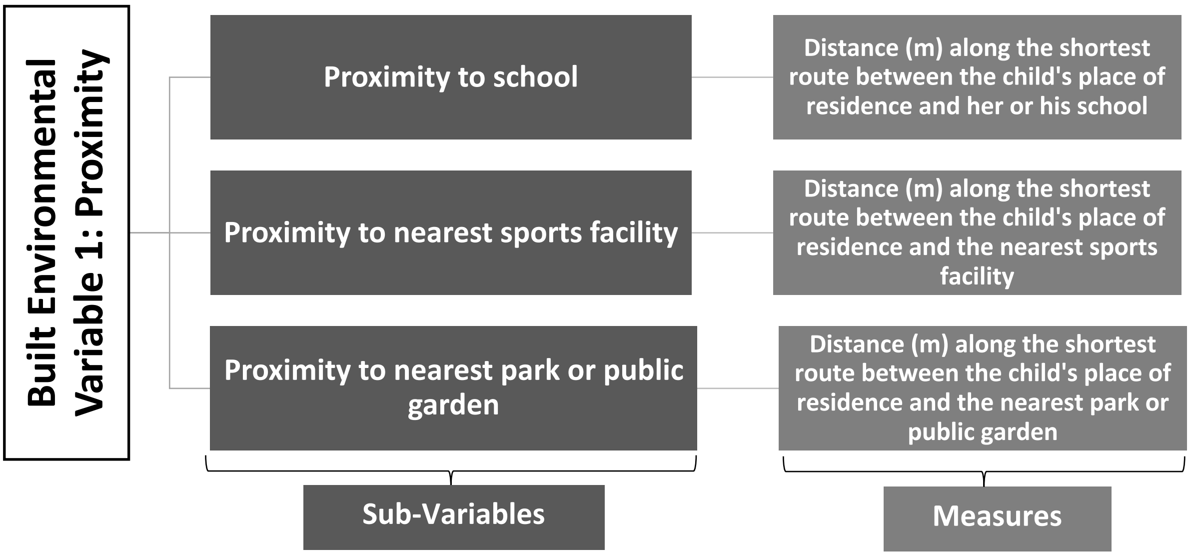


Figure 6: Built environmental variable 1 – Proximity

For the other five built environmental variables (*figure 7*), two values were calculated to examine the neighbourhood effect on a child's propensity to walk or cycle to school. On the one hand, the average built environmental variable value across all administrative units traversed by children along the shortest route to school was computed. On the other, the most extreme, 'worst-case' value encountered during their commute was retained, often assumed to be more impactful in transport decisions (Larsen et al. 2016). To explore the direct effect of the built environment on children's body composition, the values showing the strongest associations with physical activity were retained for further analysis, as the literature review emphasised the crucial role played by activity as a mediator in this relation.

A single value for each of the five variables shown in *figure 7* was included to study the built environmental impact on out-of-school, recreational activity. The direct environment close to the home, for instance the driveway, pavement, street or nearby greenspace, remains particularly pivotal to children's extracurricular play and leisurely exercise (Back et al. 2018). Hence, the immediate surroundings of the place of residence were assumed to be of greater importance than the characteristics of places further away. Therefore, when studying children's likelihood to engage in extracurricular sports and exercise, the selected value for each built environmental characteristic was the one observed in their Output Area or LSOA of residence.

The second built environmental variable included in the spatial epidemiological study, traffic risk in the home neighbourhood and along commuting routes, may impact children's activity decisions and weight status. The same risks may emerge in relation to personal safety, the third variable. Whilst the literature review showed that subjective perceptions play a strong role in determining children's activity, consistent evidence is lacking on whether objective accident and crime rates significantly influence these decisions. Therefore, traffic risk was included as the objective 2011 rates of 'accidents with injury' in London LSOAs. Accident data were collected by the Department for Transport (2014) and categorized as <20.0, 20.0-39.9 or ≥40.0 accidents with injury per 10,000 inhabitants. Personal risk was calculated using 2010/2011 crime rates, based on the total number of notifiable offences in the LSOAs children passed. These data were collected by SafeStats London per financial year, and made available in the 2011 London LSOA Atlas (GLA 2014a). They were subdivided into three dimensionless categories: <90.0, 90.0-109.9 and ≥110.0.

The Combined Emissions Index available in the same database was used as the measure for air pollution, the fourth variable, for which conclusive evidence is lacking in present literature (GLA 2014a). Exploring this association is crucial, however, as UK research highlights that children walking to school are exposed to higher pollution levels than passive commuters (Dirks et al. 2016). Nitrogen Oxide, Nitrogen Dioxide and Particulate Matter (PM_{10}) concentrations were combined to assign an overall air quality score to each LSOA. As pollutant concentrations are closely related to local motorized vehicle exhaust (Ferm & Sjöberg 2015), this also served as a proxy for traffic density. This dimensionless index was subdivided into three categories: <90.0, 90.0-109.9 and ≥110.0.

Fifth, the quantitative study also presented a perfect opportunity to test the effect of walkability on primary schoolchildren's physical activity and weight status in London. To that end, the walkability index for London Output Areas developed by Stockton and colleagues (2016) was used, combining the three neighbourhood characteristics traditionally associated with adult active commuting: residential dwelling density, density of three- or more-way junctions and land use mix. For this third characteristic, the set of land uses considered explicitly included recreational land accessible free of charge and spaces for entertainment, culture and recreation (Stockton et al. 2016), deemed crucial for children's extracurricular physical activity in the public space. The walkability quintile scores for the 2011 Output Areas were selected as the walkability measure in this study.

Finally, children active in the public space are directly exposed to the foodscapes in their surroundings. Aside from being directly related to adiposity, the literature review showed that the foodscape could potentially be linked to children's activity levels, a link which deserves further exploration. The selected measure was the categorized density of convenience stores in a one-mile radius around the postcodes the child crossed during the commute (≤20, 21-50, 51-80 or >80 stores/mile^2). These data were collected as part of the Food Environment Assessment Tool (FEAT) project (MRC Epidemiology Unit Cambridge 2017), and shared by the project team for use in this study on the postcode level for Boroughs in which SLIC children resided. Data were available on the Borough-level for Boroughs without SLIC residents. The earliest available data, from 2014, were used. While these were collected one to three years after the SLIC data, relative differences in the food environment were assumed not to have dramatically changed over this relatively brief timespan.

Due to mismatches in the periods during which these built environmental data were collected by the various data providers, as well as differing frequencies of data collection, it was not always possible to include data from the same year for the six included environmental variables. While this might entail minor inaccuracies in the subsequent statistical analyses, studying source data across various years of data collection highlights the slow pace of relative change of these variables across space and time. Therefore, it is assumed that the included data are representative across the SLIC data collection period.

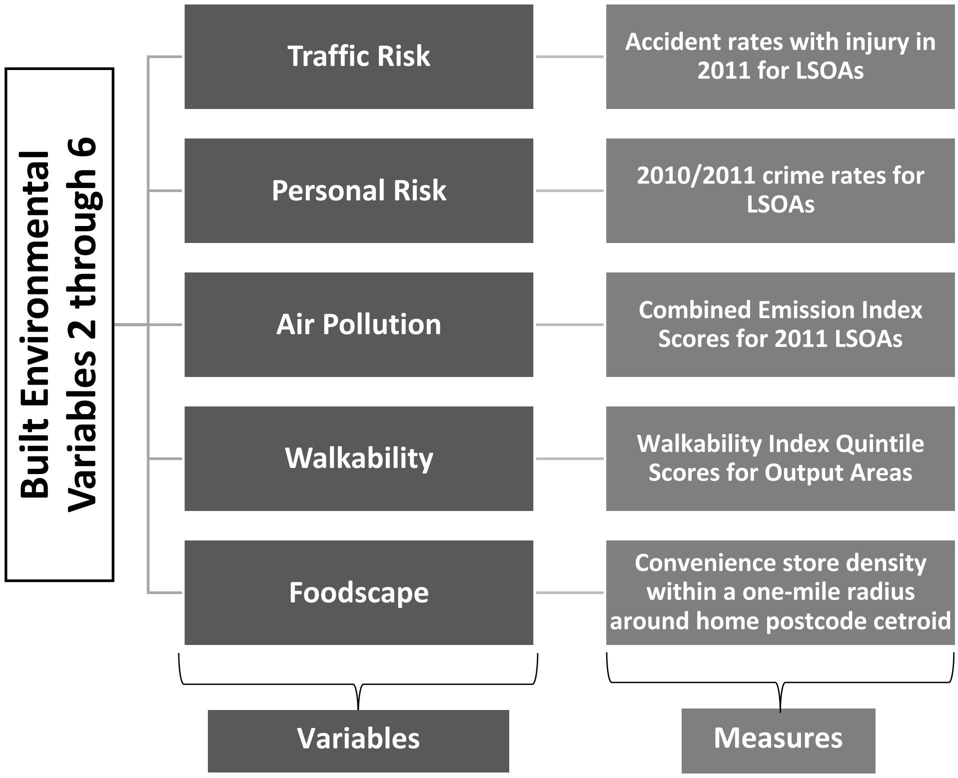


Figure 7: Built environmental variables 2 through 6

Bringing together the identified built environmental, activity and body composition variables, the final triad employed in this quantitative study is shown in *figure 8*.

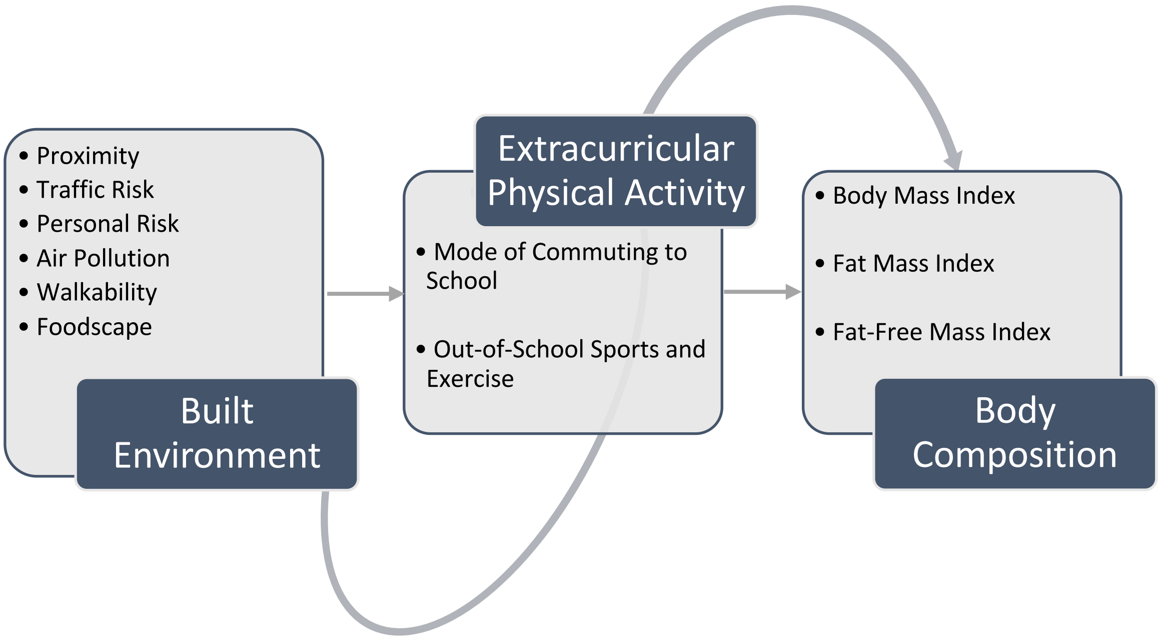


Figure 8: The triad of built environment, physical activity and body composition employed in this study

Potential Confounders and Mediators

The dynamics at work in this triad may be mediated or confounded by children's individual or family characteristics, or by socioeconomic attributes of the London neighbourhoods in which they reside. Hence, to account for this context-specificity and enable the distinction between the varying trends affecting different population groups, a wide-ranging series of potential mediators and confounders was included in the spatial epidemiological study.

Data on sex (male or female), age (in years) and attended school of participating children were collected by the SLIC team during the school visits. Parents and guardians were asked to provide detailed information on their child's ethnicity via a questionnaire (Lum et al. 2015a;b). Based on this information, children were categorized into three main ethnic groups: black (African or Caribbean ancestry), South Asian (Indian, Pakistani, Bangladeshi or Sri Lankan ancestry) and white/other (European/other/mixed ancestry). In a UK context, this collection and classification of ethnicity data is common. As membership to an ethnic group is self-defined, subjective, variable and multifaceted, this information is collected through self-reporting (ONS 2020). For the analyses, the 'other' category was added to the 'white' category as over 70% of the 364 children belonging to this group of whom the ethnicity was known were half white, by far the largest proportion of any ethnicity. London-wide ethnicity data on the spatial distribution of white and of Black, Asian and Minority Ethnic (BAME) populations were provided in the LSOA Atlas (GLA 2014a).

Socioeconomic data for SLIC children were also gathered via the questionnaire (Lum et al. 2015a). Family socioeconomic status was derived from an inventory of material possessions, summarized in the Family Affluence Scale (FAS) and classified as 'low', 'moderate' or 'high' family affluence (Currie et al. 1997). Car ownership (zero to two cars) was accounted for separately, given its decisive role in commuting choices (Ermagun & Samimi 2015; Yu & Zhu 2016). Whether or not the child received free school lunches, a reliable indicator of socioeconomic disadvantage in the UK (Ilie et al. 2017), was included as a final indicator of family socioeconomic status. Using the child's postcode of residence, neighbourhood socioeconomic status was categorized into 'low', 'moderate' or 'high' deprivation using the 2010 Index of Multiple Deprivation, combining 38 weighted variables across seven domains of deprivation for small-area units (Department for Communities and Local Government 2011; Ministry of Housing, Communities & Local Government 2020).

Having defined and operationalised the body composition, physical activity and built environmental variables, as well as potential confounders, the institutions that hold the copyright to these valuable, publicly accessible data sources should be acknowledged. The data on sports facilities, parks and public gardens remain copyright of Greenspace Information for Greater London, its licensors and/or the data providers, as applicable. Source data on traffic risk, personal risk, air pollution, children's Borough-wide physical activity, overweight on the MSOA level, the Index of Multiple Deprivation and the BAME population in London contain public sector information licensed under UK Open Government Licences v2.0 and v3.0. The FEAT dataset is developed at the University of Cambridge's MRC Epidemiology Unit, which retains the copyright and database right (© 2017 CEDAR/MRC Epidemiology Unit). The underlying food environment data contain Ordnance Survey, Open Street Map and Open Government data, subject to copyright (Map data © OpenStreetMap contributors; © Crown Copyright and Database Right 2017, OS(100059028); Contains National Statistics data © Crown copyright and database right 2017; Includes data licensed from PointX © Database Right/Copyright 2017 and OS © Crown Copyright 2017. All rights reserved. Licence number 100034829). Finally, the London Walkability tool data remain subject to copyright by the UCL Street Mobility Project, in the framework of which the Walkability Index for London was developed.

iii. Data analysis protocol

SLIC participants for whom anthropometric, body composition, physical activity or Index of Multiple Deprivation data were lacking, or who were considered to be unhealthy at the time of data collection, were excluded from further quantitative analysis. For the remaining sample, the spatial epidemiological study constituting the first stage of my explanatory sequential mixed-methods research followed a classic three-step data analysis protocol, combining cartography, exploratory statistics and formal data modelling. This protocol is frequently applied in Health Geographical research for the in-depth study of the associations between a health outcome of interest and its potential social-environmental drivers throughout space (Gatrell & Elliot 2014).

Cartography

The first step comprised the spatial analysis of quantitative data based on their cartographic visualisation, shedding light on the geographical distribution of potential drivers of, and barriers to, children's levels of physical activity and overweight and obesity across London. Hence, the six built environmental characteristics, SLIC children's active commuting and recreational physical activity as well as their body composition, and two potential confounders for which city-wide data were available, ethnicity and deprivation, were mapped in ArcMap 10.5.1. Where multiple SLIC children resided within the boundaries of the same spatial unit, which was the case for 56.6% of Output Areas, the dominant value or class for that variable was shown on the maps.

When carrying out spatial analyses, it is important to bear in mind that children attending the same school and living in closer proximity to each other are likely to be exposed to more similar environmental and socioeconomic conditions. The clustering of subjects in groups might therefore lead to the violation of the assumption that observations are independent of each other (Hedeker 2003). This phenomenon, known as spatial autocorrelation, could be graphically accounted for through summary statistics such as Moran's I, providing insightful information on the spatial arrangement of variables (Rezaeian et al. 2007). The cartography in this first step was combined with descriptive statistics, providing an overview of the distribution of individual, family and built environmental characteristics of the schoolchildren included in the SLIC sample.

Exploratory Statistics

The second step then consisted of exploratory, secondary statistical data analyses aimed at examining possible binary associations between variables, using Stata 15 software (StataCorp 2017, College Station, Texas, USA). This step served to quantitatively bolster the visual evidence extracted from the cartographic representations (Gatrell & Elliot 2014). Given the ordinal nature of the categorised built environmental, physical activity and body composition variables, allowing them to be ranked, their paired interrelations were studied through the calculation of Spearman rank-order correlation coefficients (ρ_s, Lærd Statistics 2018b). These coefficients are able to indicate whether there is a monotonic relationship between two variables, as well as the strength and direction of this relationship. The binary associations between potential confounders and SLIC children's observed physical activity levels and body composition outcomes were also tested in this step. With the exception of age, all included confounders could be considered as nominal-categorical. Hence, to explore the potential interdependency of these confounding variables and categories of children's physical activity and body weight, chi-square (χ^2) statistical tests were carried out (UCLA 2020c). The rejection of the null-hypothesis for χ^2-tests shows both variables are significantly related. Lastly, age was the only continuous potential confounder to be included in the analyses. To study its relationship with SLIC children's commuting, frequency of engagement in sports and exercise, adiposity and muscle development, again, Spearman rank-order correlation coefficients were suitable for detection of a potential monotonic relationship (Lærd Statistics 2018b).

Formal Data Modelling

The exploratory statistical analyses paved the way for the third and final step of the spatial epidemiological study: formal data modelling in order to delineate the objective built environmental drivers of, and barriers to, children's activity levels and body composition. Their relative importance and pathways of influence were gauged using Stata 15. The mediating or confounding effects of children's individual and family and neighbourhood socioeconomic characteristics were also explored in this step.

Similar to what was observed for the cartography in the first step, when statistically analysing the associations of the built environment with physical activity and body composition, the nested data structure, whereby pupils are grouped by school, needed to be accounted for. Individuals attending the same school are likely to be more similar to each other compared to those attending a different school (Dickinson & Basu 2005; Peugh 2010). As the literature review demonstrated, non-white children in England are unequally confronted with socioeconomic and obesity risk factors, and deprivation itself has also been linked to obesogenic lifestyles (Falconer et al. 2014). Therefore, the distribution of and exposure to these risk factors is highly likely to differ by school, according to their ethnic and socioeconomic composition, generating the need for school-specific information to maintain the assumption of independence of observations (Hedeker 2003). Compositional effects must be distinguished from contextual ones, and, hence, the statistical models must correct for these clustering effects, which can be done in two ways (Primo et al. 2007). The first possibility is to run single-level ordered logistic regression models with cluster-robust standard errors by school. Secondly, a multilevel modelling analysis on two levels can be performed (Gatrell & Elliot 2014).

To decide upon the most appropriate statistical approach, likelihood ratio tests comparing the fit of multilevel models to that of simple ordered logistic regression models were carried out, demonstrating the added value of the multilevel structure for the overwhelming majority of modelled relations. Therefore, the choice was made to consistently rely on multilevel modelling for the statistical analyses in this third step. The first level included the independent variable of interest – either a built environmental characteristic in relation to physical activity or body composition, or a physical activity component in relation to body composition – as well as the child's individual characteristics (ethnicity, age and sex), and family and neighbourhood socioeconomic status. Together, this first level captured the specific individual, socioeconomic environment she or he was exposed to. The second level then grouped the children by school, correcting for their higher likelihood of similarity due to the exposure to more similar environments based on their place of residence and school location.

The mixed-effects regression models designed for the analysis of clustered data must be adapted to fit the ordered categorical nature of the response variables for both physical activity and body composition. Hence, I opted for multilevel mixed-effect ordered logistic modelling on the level of the individual child and the attended school as the preferred form of data modelling (Snijders & Bosker 2012).

Four key assumptions are made when using ordinal regression models (Lærd Statistics 2018a). These are: i) The dependent variable is measured at the ordinal level; ii) Independent variables are continuous, ordinal or categorical, with ordinal independent variables being treated as either categorical or continuous; iii) There is no multicollinearity of independent variables; and, iv) The effect of each independent variable on the odds of the ordinal outcome variable is identical at each cumulative split of that variable. This final assumption is known as the 'proportional odds assumption'. From the definition and operationalisation of variables above, it is clear assumptions i) and ii) were met. While no appropriate tests exist to scrutinise assumptions iii) and iv) for multilevel ordered logistic regressions, I applied single-level

Variance Inflation Factors tests to check for multicollinearity, and single-level Brant tests to investigate the proportional odds assumption (UCLA 2020a,b). Whereas no indications for multicollinearity were found and assumption iii) thus held, the Brant tests pointed out that all raw, continuous dependent variables and potential confounders failed the proportional odds assumption, with the exception of age. Therefore, these variables were categorised as outlined above, and age was included as the sole continuous variable in the ordered logistic regression models.

When studying the link between the built environment of SLIC children and their physical activity and body composition, two sets of models were designed. Firstly, associations between each individual built environmental characteristic and SLIC children's likelihood of engaging in physical activity or becoming overweight or obese were computed, fully corrected for potential confounders. Secondly, a comprehensive, fully-adjusted model including all six built environmental measures was developed, allowing assessment of the relative weight of each neighbourhood variable in determining activity or body weight patterns. In the models linking the built environment to active commuting, the choice to include either the average or extreme value measured along the shortest route to school for each neighbourhood variable was made depending on the strength and significance of their independent associations with commuting in the individual models. To study the relation between SLIC children's levels of active commuting or recreational physical activity and their rates of excess weight, similar individual models were designed, fully corrected for potential confounders.

In practice, all models were estimated using Stata's mixed-effects ordered logistic regression ('meologit') command function. Following their categorization, all explanatory variables, either built environmental or activity-related, were treated as factor variables in the models (using the 'i.' command in Stata), as were all potential confounders with exception of age, the latter being considered a continuous variable following the proportional odds test. The lowest category for each built environmental characteristic or the most frequent engagement in physical activity were consistently set as reference categories. For potential confounders, the selected reference categories were female sex, white/other ethnicity, low family affluence, no receipt of free school lunches, no family car ownership and low Index of Multiple Deprivation. On the second level of the multilevel analyses, the identification number of the schools was included in all models as the group variable. Results are shown as Odds Ratios (OR) for engaging more frequently in extracurricular physical activity or being in higher BMI, FMI or FFMI categories, with 95% Confidence Intervals (CI). The critical significance level for all models was set at $p < 0.05$, (indicated by * in the results tables), with further discretions at $p < 0.01$ (**) and $p < 0.001$ (***)

Whilst enabling a profound insight into the objective dynamics at work in the built environment-physical activity-body composition triad, several limitations of these analyses need to be highlighted. Being a cross-sectional study, causal links could not be established. The internal validity of cross-sectional studies is traditionally low (Carlson & Morrison 2009). However, the wide range of thoroughly selected built environmental characteristics and potential confounders included and the breakdown of extracurricular physical activity and body composition into their prime components limited the odds that my findings would be influenced by systematic errors or other, external causes. Next, measures of physical activity relied on subjective self-reporting, and could not be objectively verified. In addition, whilst no data were collected during the UK school summer holiday period during peak summer months (second half of July to October), seasonality potentially affecting outdoor, non-essential physical activity could not be corrected for. Finally, information on the presence of siblings and peers, parental and school attitudes to physical activity, and distances to public transport, which could arguably influence children's obesogenic or leptogenic behaviour, was unavailable and could therefore not be accounted for. The potential influence of self-reported data, seasonality, the presence of peers and attitudes to physical activity could, however, be explored in the second, qualitative stage of my mixed-methods research.

b. Stage 2 of 3: Qualitative Lived Experiences

The second stage of the explanatory sequential mixed-methods study aims to support, contradict or expand the quantitative findings through the analysis of children's lived experiences in relation to their physical activity and body shape in the multiple, fluid and changeable neighbourhoods they navigate and negotiate (Creswell et al. 2011). Aside from contributing to the clarification of quantitative findings, the qualitative stage thus opens up the possibility of adding novel insights into the dynamics at work in the triad (Schoonenboom & Burke Johnson 2017). This stage also enables remaining knowledge gaps identified in prior literature to be addressed. These include the exploration of the potentially determining role of environmental perceptions, and the gathering of micro-level evidence on influential drivers of activity and weight gain. Moreover, qualitative research allows an insight into the fuzzy nature of children's self-defined neighbourhood boundaries and their inter-relational interactions with the human and more-than-human within those boundaries.

In three parts, this section therefore describes the sampling strategy and associated ethical considerations, the methods used for data collection, and the analysis plan employed to address these gaps and construct a comprehensive and coherent qualitative argument that can be integrated with the quantitative findings in the final stage of the mixed-methods study.

i. Sample and ethical considerations

As the SLIC study was carried out between 2010 and 2013, participants included in the dataset had left primary school by the time of my qualitative fieldwork. A new, equally diverse sample of contemporary London primary schoolchildren was therefore selected whose real-life experiences could be explored. Arguably the core question when building such sample is the determination of the number of interviews necessary to draw meaningful conclusions based on a wide and holistic set of qualitative data.

A plethora of academic publications have discussed this question, often coming to vastly different conclusions and leading to the observation that *"it depends"* (Baker & Edwards 2012, p.42). Nonetheless, more rigorous analyses attempted to estimate the number of interviews required to attain exhaustive thematic saturation, the point at which no new information or themes are observed in the data (Guest et al. 2006). These delivered a wide variety of figures, ranging from less than twenty to several hundreds of interviews (Weller et al. 2018). There is, however, consensus that the salient themes present in people's narratives emerge from sample sizes ranging between less than ten to just over twenty interviews (Guest et al. 2006; Hennink et al. 2017; Weller et al. 2018). As I wanted to ensure the emergence of these salient themes from my interviews, I aimed for a reliable sample size of circa twenty interviewees attending each of three different schools in London. This resulted in a total of around sixty participants for the qualitative research stage.

To ensure the inclusion of a wide variety of perspectives and higher transferability of the findings, a maximum variation sampling strategy was applied for the selection of participants (Palinkas et al. 2015). This implies purposefully selecting schools from London Boroughs with high levels of childhood overweight and obesity, strongly diverging socioeconomic status, and a diverse ethnic composition. Personal characteristics then formed the basis for participant selection within each school. The sample was stratified by gender and self-reported ethnicity, with a similar number of boys and girls, and black, South Asian and white/other children being included. To avoid selection bias and stigmatisation, the overarching focus of the research on the body composition of children was mentioned in information booklets for parents and children, but did not constitute a core selection criterion or focus of the qualitative interviews. It was assumed that children of all body shapes would be included due to the maximum variation sampling strategy. Out of the larger group of primary schoolchildren, pupils in Year 3 to Year 5 were invited to participate, aged between seven and eleven years. The choice of this group of children in Key Stage 2 was motivated by their ability to process a significant amount of information and, through stable and logical reasoning and based on their verbal capacities, form a conclusion considering all sides of a situation (Jarvis 2015). Children in Year 6 were excluded due to their participation in Standard Attainment Tests during the school year, limiting their time and flexibility to participate in the research.

Access to the schoolchildren and their parents or guardians was negotiated through the headteacher of the school they attended, acting as a vital gatekeeper. Only after the school's formal approval were potential participants contacted. To gather participants, I reached out to parents and guardians (further simply referred to as 'parents') and pupils during parents' evenings in schools, explaining the research. Both parents and children were then invited to open research presentation sessions organised before, during and after school on a suitable school day, where further details were provided and informed consent forms distributed.

UK law, under the Children's Act, foresees the need for parents to consent to children's participation in research on their behalf until they reach the age of majority (Lambert & Glacken 2011). However, carrying out ethical research transcends simply adhering to formal stipulations, and involves the ongoing critical reflection on and self-assessment of applied attitudes, values and assumptions. I adopted an integrated post-developmental and post-childhood perspective. This implies that the child's voice takes centre stage, respecting her or his subjective, context-specific experiences as an interdependent social agent, aware of power dynamics at work in the adult-child research relationship (Graham et al. 2013; Nansen et al. 2015). At the same time, children's societal and individual vulnerability and relationality are recognised (Graham et al. 2013). Therefore, rejecting a developmental perspective of the child and recognising their cognitive abilities, this study also explicitly asked children to give free and fully informed consent, tailored to their level of understanding and stipulating the voluntary nature of participation and of the continuously renegotiable and withdrawable consent (Cocks 2006). The informed consent forms, elaborating the aim of the research and its methodology, the assurance of anonymity, the recognition of the potential disadvantages to participation and the adherence to the Data Protection Act, can be found in *Appendix 1*.

These ethical considerations constituted a prime focus during the study design, and remained so throughout the entirety of the project. Ethical approval to carry out the qualitative research stage was obtained from the REC at the Department of Geography, University of Cambridge, UK (Ethics Assessment Number 698). Moreover, I obtained an Enhanced Disclosure and Barring Service Certificate, allowing me to undertake interviews with schoolchildren.

Selected children were invited on a day trip to Cambridge, UK, upon the conclusion of the fieldwork, to thank them for their participation. This day, offered to the pupils free of charge, consisted of a visit to the Museum of Zoology, where children interactively explored animal life guided by Museum volunteers, a lunch in the Hall of Gonville & Caius College Cambridge, a tour of the city and a lecture about the life of University of Cambridge students. The school trip was generously supported by the Museum of Zoology, the School Liaison Office at Gonville & Caius College Cambridge, and Brent Borough Council, with logistical support from the schools.

ii. Data collection methods

To enhance the depth and breadth of the qualitative information collected, a multiple-method study design was selected. This implies gathering an extensive set of data from different sources, each requiring a different form of analysis. Three data collection techniques were combined: go-along interviews supported by qualitative GIS, field notes and photography, accelerometry, and activity diaries. Together, these result in a comprehensive qualitative study, supported by quantitative methods, to which the same priority is attached as the first, spatial epidemiological research stage. Each of these methods requires detailed discussion.

Go-Along Interviews

Listening to children's voices and exploring their physical body movements as they unfold in real time and space requires researchers to immerse themselves into these children's habitats (Kusenbach 2003). Major limitations of the two dominant, traditional qualitative data collection methods – participant observation and sit-down interviewing – make them unsuitable for this purpose. In participant observation, studied subjects do not spontaneously explicate or clarify the reasoning behind nor the meaning of their natural day-to-day actions and activities, nor the way they perceive and experience their environment. During static, sedentary interviews, subjects are restrained from engaging in those activities in specific places, and can only refer to them verbally (Kusenbach 2003).

Therefore, a third, novel interviewing technique lies at the heart of the second, qualitative stage of my explanatory sequential mixed-methods research: the go-along interview. This hybrid technique, which has rarely been trialled with children prior to my study, blends traditional interviewing with direct observation of real-life settings, as the researcher-interviewer accompanies individuals on outings in their local environments, allowing personal *"time-space biographies"* (Cummins et al. 2007, p.1830) to be constructed (Carpiano 2009). This technique is particularly appropriate in mobility research and when the impact of place on health and wellbeing is studied (Carpiano 2009; Evans & Jones 2011). Go-alongs tend to be more spatially focused than sedentary interviews, generating place-specific rather than autobiographical narratives (Evans & Jones 2011). In analogy to the observations made for disabled bodies (Castrodale 2018), these interviews with children can at the same time uncover the socio-spatial privileges of able, adult bodies, as well as institutional layers of oppression towards children inscribed in space. Issues of representation, authenticity and power remain at stake, as is the case in all research productions. However, the methodological strength of the go-along interviews and the critical reflection on these issues allow the messy, multi-layered and non-normative character of children's voices to be accounted for (Spyrou 2011).

Nonetheless, it should be recognized that the success of such interviews depends in part on factors beyond the control of the researcher, including human characteristics and environmental conditions (Carpiano 2009). The physical abilities of the interviewee may limit the time and distance travelled, and the time of day and year and the local weather may influence social interactions and road activity. Therefore, personal and road safety needed to be prioritized at all times. Technical issues such as equipment failure and poor quality of recording could also throw a spanner in the works. Moreover, for safeguarding reasons, it was not possible to carry out the interviews alone with individual children. An accompanying adult had to be present, who was not supposed to participate in the interview. This person could be a parent, guardian, teacher, adult sibling, or part of a larger group walking to school or in the neighbourhood – the research design was flexible on this point. Luckily, the pilot study I carried out as part of my previous MPhil degree allowed to test various formats in practice and make allowances for these potential hiccups.

Following this pilot, I settled on two forms of go-along interviews for my doctoral study. A first set was carried out while accompanying the children during their regular daily school commute. For actively commuting children, the interview was a walk-along interview while walking to or from school. Because interviewing while cycling entails significant risk, children who normally cycled to school were asked to walk for the interview, if the distance to school allowed. For passive commuters, the interview constituted a drive-along in a private car or using the regular mode of public transport. The second set consisted of walking tours, guided by the child, through her or his home neighbourhood, along a route set out by the participant. Along the way, the child was designated the role of local expert, uniquely positioned to make meaning of the environment (Garcia et al. 2012).

The semi-structured, child-led interviews consisted of three crucial phases, guided by the interview protocol attached in *Appendix 2*. Firstly, prior to the start of the interview, the interviewer orally introduced the child to the go-along, the research aims and its components. This was also an attempt to put the participant at ease and encourage active engagement, inciting her or him to take the lead. Secondly, during the interview itself, the child was prompted to voice built environmental experiences related to physical activity, starting from a topic list based on the quantitative findings. These topics centred around the six included objective built environmental characteristics and children's own, subjective experiences of their surroundings and behavioural patterns. The topic list was, however, used in an open framework and therefore differed slightly depending on the type and setting of each interview. This permitted a freely flowing, two-way conversation between interviewee and interviewer, in which new observations emerged naturally (Carpiano 2009). Additional questions were asked to gather more detailed information on the facilitators or barriers discussed by the participant or those not mentioned but deemed important from the quantitative stage. Finally, at the end of the interview, the children and accompanying adult were thanked for their participation, any remaining questions answered, and further proceedings explained.

The interviews were audio-recorded, supported by photography by the interviewer of built environmental elements pointed out by participants and supplemented with handwritten direct observations of their activity behaviour, non-verbal communication and researcher's reflections. This real-time generation of contextual data on factors related to activity behaviour sets it apart from other activity data collection tools such as accelerometry or activity diaries (Loprinzi & Cardinal 2011).

A handheld GPS device was used to track the followed route. The recording of spatial coordinates permitted the construction of spatial transcripts, as excerpts from the recorded narratives could be accurately linked to their exact location. Spatially observed relationships and patterns of mobility and built environmental perceptions could thus be visualized through Qualitative GIS (Jung 2009). The chosen GPS system was a Qstarz BT-Q1000XT (*figure 9*, Qstarz International Co. Ltd., Taipei, Taiwan), and recorded spatial coordinates were imported into ArcMap 10.5.1. These digitised routes also allowed me to reiterate each route independently, to gather

Figure 9: Qstarz BT-Q1000XT GPS employed (qstarz.com)

additional photographic evidence and observational notes. This information supplemented the verbal data, documenting sights, smells, sounds and impressions as or shortly after they occurred, encouraging the identification of and reflection on bias, and provided essential context and critical, non-verbal content to inform data analysis (Phillippi & Lauderdale 2018).

Accelerometry

The choice of the second main data collection technique employed during this second research stage stemmed from an interest in participants' day-to-day activity levels. Through the collection of objective data, an insight could be gained into their total physical activity gathered during a standard school week, and the potential differences in extracurricular activity between weekdays and weekend days. Though this information can be collected in a multitude of ways (Loprinzi & Cardinal 2011), the age of the children, the sample size and the respondent burden were decisive factors in the choice of accelerometry, considered to be the gold standard for free-living physical activity assessments (Bornstein et al. 2011).

During the go-along interview and the week thereafter, children were asked to wear an accelerometer, a small, light and reusable tool that objectively assesses activity levels by converting recorded accelerations along three dimensional axes into quantifiable digital signals called 'activity counts' (Sirard & Pate 2001). Accelerometers are widely adopted in activity studies today, although their limited ability to accurately assess cycling and activity on a topographic gradient should be recognised (Loprinzi & Cardinal 2011). The selected accelerometer was the triaxial Axivity AX3 accelerometer, a robust device with a battery life of several weeks which is easy to attach and remove, even for a child, and weighs no more than eleven grams (*figure 10*, Axivity Ltd., Newcastle-upon-Tyne, UK; Prioreschi et al. 2018).

Figure 10: Axivity AX3 accelerometer employed (axivity.com)

The accelerometer records minute-by-minute Metabolic Equivalent of Task (MET) activity units, a physiological measure expressing the energy cost of physical activities. One MET is the energy expended by an individual while seated at rest, equivalent to an energy consumption of 3.5 millilitres of oxygen per kilogram of body weight each minute (Jetté et al. 1990; WHO 2019). The MET boundaries for children for light-intensity physical activity have been set between 1.5 and 4 METs, whereas those for moderate and vigorously intense activity have been set at 4-7 and >7 METs respectively (WHO 2019). These MET data cut-offs recorded by the AX3 can then be translated into minutes of 'Sedentary', 'Low', 'Moderate' or 'Vigorous' activity intensity for children, an automated process using the open-source OmGui software provided by Axivity (Open Lab Newcastle University 2020). This allows the calculation of whether participants meet minimum activity requirements, during what periods of the day their activity takes place, and with what intensity.

Participants were asked to wear the AX3 at all times during waking hours on their non-dominant wrist, shown to entail the highest wear compliance in children (Duncan et al. 2019) whilst reducing interference with writing and other activities for which the dominant wrist is used. The absence of a screen allowing participants to track their activity was also assumed to minimise the stimulation of additional, irregular activity, aiding the recording of activity resembling a 'standard' week. The accelerometer was not worn when performing activities that involved water, such as bathing or swimming, to protect the device from accidental damage and malfunction (Adams et al. 2013).

Activity Diaries

The third and final data collection method, activity diaries, then provided context and elaboration to the objectively collected accelerometry data, and enabled the recording of water-based activities and cycling. Moreover, gathering both quantitative and qualitative activity data allowed the comparison of self-reported and objectively assessed activity levels (Loprinzi & Cardinal 2011). Each evening for one week following the go-along interview, participants were asked to complete a diary in which they recorded the type and duration of all physical activity they had engaged in during that day. As children may have limited ability to accurately report activity patterns (Loprinzi & Cardinal 2011), tick-box forms were provided from which children could select the relevant mode of commuting to and from school, as well as the series of activities they engaged in from a predefined list, alongside the duration of each. The list contained activities ranging from sedentary and screen-based to vigorously intense. A box at the bottom of each page then allowed children to further elaborate on their day should they have chosen to do so. Each day of the week was assigned a different colour, and sheets were arranged to start on the day of the interview and bound together in a plastic folder. A relative was allowed to assist with the completion of the diary, and pens were provided. Examples of diary sheets for a school day and weekend day are shown in *figure 11*.

FRIDAY

1) How did you travel to school today? Please tick:

Walking	Cycling	Car	Bus	Tube	Other:___________

How long did that take you? Please tick:

Less than 10 minutes	10 to 30 minutes	More than 30 minutes

2) How did you travel home again after school today? Please tick:

Walking	Cycling	Car	Bus	Tube	Other:___________

How long did that take you? Please tick:

Less than 10 minutes	10 to 30 minutes	More than 30 minutes

3) Did you do any of the following things today? When? Please tick, and write down how long you did them for in the last column:

Which Activity?	Before School	During School	After School	How long? (minutes/hours)
Running/Jogging				
Cycling/Scootering				
Football				
Dancing				
Tennis/Badminton				
Swimming				
Basketball				
Playing outside				
Trampolining				
(Dog) Walking				
Watching TV				
Gaming				
Surfing the internet				
Other sport/activity: __Gymnastics____				

Did you do any other activity today you'd like to tell me about?:

SATURDAY

Did you do any of the following things today? When? Please tick, and write down how long you did them for in the last column:

Which Activity?	Before Noon	Noon to 5pm	Evening	How long? (minutes/hours)
Running/Jogging				
Cycling/Scootering				
Football				
Dancing				
Tennis/Badminton				
Swimming				
Basketball				
Playing outside				
Trampolining				
(Dog) Walking				
Watching TV				
Gaming				
Surfing the internet				
Other sport/activity: _____________				

Did you do any other activity today you'd like to tell me about?:

Figure 11: A weekday and weekend day activity diary sheet

iii. Data analysis protocol

The three main data collection methods in the qualitative stage produced a wealth of raw information requiring adequate processing to delineate perceived barriers to, and facilitators of, children's physical activity in their built environments. Together, these data provided a detailed account of their lived experiences in the outdoor public space as children of varying age, sex, ethnicity and body shape.

<u>Go-Along Interviews</u>

The analysis of the go-along interview transcripts, the first data collection method, followed a two-step process. First, the narratives were transcribed verbatim and prepared for coding using the qualitative data analysis software NVivo 12.0 (QSR International Pty Ltd. 2018, Doncaster, Australia). Field notes and photographs taken were added to these transcripts as comments at the relevant point during the interview, and serve as background information to the narrative to be analysed. That way, each prepared transcript can be considered as an individual unit of analysis: large enough to be considered in its entirety, but small enough to be kept in mind as context for the meaning or coding unit – the constellation of words or statements that relate to the same central meaning – during the analytical process (Graneheim & Lundman 2004).

Secondly, for the de facto analysis of transcripts, a thematic analysis methodology was selected and applied, following the guidelines by Braun and Clarke (2006), leading proponents of this form of analysis. Presented as an independent, fairly straightforward qualitative descriptive approach deserving more attention in health research (Neergaard et al. 2009), thematic analysis allows the identification, analysis and reporting of patterns or themes within data (Braun & Clarke 2006). This implies stepping away from a focus on quantities or frequencies in qualitative data analysis through the provision of a purely qualitative, detailed and nuanced account aimed at capturing participants' lived experiences, views and perspectives (Clarke & Braun 2017; Vaismoradi et al. 2013). This has the potential to unravel the performative aspects of children's outdoor activity behaviour, and to provide an insight into the multitude of partial voicings that make up their story. Furthermore, thematic analysis allows the analysis of meaning to be combined with the context in which this meaning arises (Loffe & Yardley 2003), highly relevant for the explicit awareness of context-specificity this research propagates in contrast to prior studies. In so doing, the risk of losing or actively removing meaning from context through an excessive focus on coding frequencies is limited (Vaismoradi et al. 2013). This makes thematic analysis particularly suitable for the aim of my study: to extract information from the go-along interviews with the objective of determining the potential relationship between variables and comparing different sets of evidence from the mixed-methods study (Alhojailan 2012).

A thematic analysis approach can be used for both data-driven, inductive analyses and theory-driven, deductive analyses (Braun & Clarke 2017). I aimed to substantiate or contradict the quantitative findings from the first stage of the mixed-methods study whilst also allowing additional information to emerge from the interview data. Therefore, I opted for a cyclical movement back and forth between in- and deductive analyses, applying an abductive, or complementary, approach (Graneheim et al. 2017). Adhering to an abductive paradigm implies testing a hypothesis emerging from data – in my case from the first, quantitative stage – while at the same time allowing new ideas to surface, thus overcoming the inductive-deductive dichotomy (Nunes Moscoso 2019).

In the qualitative stage, therefore, the deductive element constitutes the examining of the set of six potentially relevant built environmental characteristics and the series of included confounders formulated in the prior, quantitative stage along the axes of the ecological frameworks for child physical activity and overweight and obesity. This a priori, theoretically-determined knowledge, translated into deductive themes, initially directs the analytical approach to the transcripts in a non-stringent manner (Assarroudi et al. 2018). However, this leaves plenty of room for the inductive element: the discovery of meaningful underlying patterns and the incorporation and interpretation of data that do not fit the deductively developed themes (Graneheim et al. 2017). Through the abductive approach, new themes can thus be extracted from the database, which can refine or even overrule the set of a priori, deductively established themes. Combining deduction, induction and abduction in a cyclical manner, it then becomes possible to develop and add to the findings from the quantitative study, and to evaluate and expand the ecological models designed in the conceptual framework.

Translating this abductive thematic analysis theory into practice, I followed Braun and Clarke's (2006) six-phase analytical framework. This useful guide offers a transparent structure with a clearly defined, though not necessarily linear, sequence of six analytical stages, increasing the trustworthiness of the analyses (Maguire & Delahunt 2017; Nowell et al. 2017; Vaismoradi et al. 2013):

- *Phase 1: Familiarising yourself with the data*

This phase encompassed the transcription process and the active reading and re-reading of the transcripts to fully get acquainted with the richness of the collected qualitative data. Potentially relevant passages or quotes were highlighted, notes and photographs added to the transcripts, and first thoughts and impressions written down. This generated an overall list of ideas about the content and breadth of the data available in preparation of the formal coding.

- *Phase 2: Generating initial codes*

The second phase signalled the start of the systematic organisation of collected data. The first round of coding in NVivo divided the overwhelming amount of verbally produced information into small chunks of meaning. A single code is the most basic unit of raw data that can be meaningfully assessed with regard to the phenomenon under study.

I wanted to place the child's voice at the heart of the analysis. Therefore, I explicitly opted to stay close to the manifest, explicit meaning of children's narratives in the transcripts at this stage, refraining from in-depth interpretation while identifying a maximum number of relevant codes. Each coded segment describing how children experience their surroundings in relation to their physical activity or body composition was thereby allocated one or multiple relevant shorthand labels. These include deductively established, theory-driven codes stemming from the findings of the quantitative stage, as well as new, inductive codes arising from the interviews themselves. The abductive approach also allowed pre-conceived codes to be modified. Some example of codes from the interviews, with anonymous unique participant identifiers, are shown below (*figure 12*).

Coded segment of transcript	Code assigned to extract
"We come for the BMX track." (I10_S1)	Presence of recreational facilities
"I fly my kite on this park thing. And that's it. There's nothing else to do." (I11_S2)	Absence of recreational facilities
"The thing is, I hate cars. Cars come past and they go so fast, and they splash the street." (I16_S1)	Presence of motorised vehicles; Speed and driving style

Figure 12: Examples of initial transcript codes

- *Phase 3: Searching for themes*

The items of interest identified in the second phase formed the basis of the delineation of repeated patterns or overarching themes across the dataset in the third phase. A theme can be considered as a meaningful set of data responses capturing relevant information in relation to a specific aspect of the research question. For instance, the codes referring to the 'presence of motorised vehicles' required attention, as they tend to be closely intertwined with observations of traffic safety in the outdoor, public space. In first instance, themes were related to the predefined set of built environmental elements developed in the quantitative stage and conceptual ecological models. However, the remaining codes that did not fit these deductive categories were assembled in subsequent rounds of inductive thematic development, thereby expanding, changing and refining the a priori established analytical framework. Eventually, this phase returned a list of predefined, modified and novel candidate themes and subthemes.

- *Phase 4: Reviewing themes*

Having established this list of grouped codes addressing the same aspect of the research question, themes were checked both in relation to all coded extracts that are part of them, as well as in relation to the overall dataset. In order to achieve maximum internal homogeneity and external heterogeneity of themes, themes supported by insufficient data were merged to form a single, overarching themes, whereas others were broken down into relevant, constituent parts. Once again, new potential themes could emerge from this phase due to the restructuring and reviewing of candidate themes. This resulted in a refined thematic map of themes and subthemes.

- *Phase 5: Defining and naming themes*

Having robustly outlined the grouping of relevant information, the essence of each theme could then be identified, as well as the interrelations between themes and their fit in the overall message the research is trying to convey. Led by the conceptual framework, the ecological models were now substantiated and concretised, as codes and themes were fitted into the relevant constituent vertices of the triad. In first instance, the focus here was on fitting data into the population and physical environmental vertices, pivotal cornerstones of my research. Once this process was completed, remaining themes were scrutinised and added to the triad as complementary facets.

- *Phase 6: Producing the report*

Finally, the thematic analysis needed to be written down in a way that convincingly tells the complex, multi-layered story narrated by the collected data, all the while demonstrating the merit and validity of the performed analyses. The qualitative chapter of my dissertation aims to present this story, feeding back into the reviewed literature and conceptual framework. In so doing, I rely extensively on verbatim quotes in an attempt to place children's voices, lived experiences and opinions at the forefront of academic discovery, and to provide policy-relevant evidence in the language of those targeted and most affected by interventions.

Children's literal, spoken word represents a powerful tool to demonstrate the value of their narrative. Moreover, the verbatim inclusion of their opinions and experiences truly delivers on the promise to grant participating children the opportunity to express their own views, albeit recognising their interdependency and partiality. Selecting the most relevant or illustrative quotes is a challenging task, and I rely on Lingard's (2019) notion of authenticity in this process. This ensures the used quotes succinctly represent the pattern discovered in the data, and clarify the key argument made. At the same time, I believe this strengthens the credibility of the research (Cordon & Sainsbury 2006). The photographs and field notes are used here in the same manner. Finally, through qualitative GIS, overview maps of the traversed routes are produced to situate the interviews in their concrete geospatial location in London.

Accelerometry

The information gained from the thematic analysis of the interviews is then complemented by the objective accelerometry data, collected during the week following the go-alongs. Upon conversion of METs into minutes of sedentary, light, moderate or vigorous physical activity through the OmGui software, the activity pattern of each child could be plotted. A minimum of six hours of wear-time during waking hours from 7.00am to 10.59pm has been established as the lower boundary to count as a valid day of observation. Moreover, a minimum of two valid measurement days is required to be considered representative of the activity of an older primary schoolchild (Rich 2013).

As I am interested in the variations of children's activity throughout the week, the minimum inclusion criteria were set at six hours or more of recorded activity for at least three days, including at least two weekdays and one weekend day. Hours were excluded if they consisted of 60 consecutive minutes of zero-value activity counts, with an allowance of up to two minutes with limited activity counts, assumed to be due to measurement error (Adams et al. 2013). If children accumulated 60 daily minutes of MVPA, this was recognized as meeting the international guidelines for daily child physical activity. These data were then broken down by age, gender, ethnicity and socioeconomic status, as well as geographic location. Furthermore, as accelerometers precisely identify when children are active, the proportion of this activity taking place outside of school hours on weekdays and on weekends could be identified.

Activity Diaries

Finally, aware of the generally lower reliability of self-reported activity by children under ten years of age, the activity diary data were used as supplements to the quantitative accelerometry (Loprinzi & Cardinal 2011). Children's frequency of engagement in various forms of physical activity was counted, and their dominant modes of commuting grouped. Once again, these data were broken down by school. Additional information written down by the child has been used to add to their narrative collected during the go-along interview.

c. Stage 3 of 3: Integrating the quantitative-qualitative study sequence

The final stage of the explanatory sequential mixed-methods design concerns the integration of quantitative and qualitative findings to answer the third central research question. All too often, this stage consists of simply presenting the findings from both prior research stages alongside each other, without their actual integration (O'Cathain et al. 2010). Moreover, researchers have frequently focused on a purely empirical unification of their results, side-lining the relational construction of a comprehensive, theoretical explanation of particular phenomena (Tunarosa & Glynn 2017).

Aware of these potential pitfalls, in this dissertation, findings from both research stages have been validated and interpreted through triangulation (O'Cathain et al. 2010). This enables their meaningful integration and the creation of new knowledge, theory and policy proposals around the dynamics at work in the built environment-physical activity-body composition triad. The coherence of quantitative and qualitative results are stringently scrutinized, leading to three possible outcomes (Fetters et al. 2013). Firstly, confirmation occurs when both data types support each other's outcomes. Next, expansion arises when the sources complement each other or highlight different aspects of the phenomenon under study, generating novel insights and pathways for further research, a characteristic unique to triangulation (O'Cathain et al. 2010). Lastly, if findings are inconsistent, this is labelled as discordance. The diverging yet complementary nature of the quantitative and qualitative paradigms makes it likely discordance will emerge (Moffatt et al. 2006). Whatever the relation between the results of both prior stages, their dialogue leads to a deepened understanding of how the built environment stimulates or hampers children's physical activity and impacts their weight. The conclusions differ significantly from those that would have been obtained if only one method had been used (Moffatt et al. 2006). It is precisely because of the need for complementarity and expansion that a mixed-methods approach has been chosen (Bryman 2006).

In practice, the triangulation protocol involved the production of joint displays, where coded themes emerging from the quantitative and qualitative stages are presented together (Guetterman et al. 2015). This side-by-side comparison constituted the basis for an integrated analysis of their respective confirmation, expansion or discordance, generating new insights into, and enabling increased understanding of, the built environment-body composition relation, mediated by children's physical activity (Guetterman et al. 2015).

VI. Key takeaways from the methodological chapter

The explanatory sequential mixed-methods research design outlined in this chapter guarantees maximum methodological and analytical rigour. The wide variety of collected data provides ample opportunity for sound data triangulation, supported by the representative sample of SLIC children in the quantitative stage and the go-along interviews participants selected through maximum variation sampling. The reliability of data is further increased by the richness of the field notes, photography, accelerometry and activity diaries, documenting all aspects of children's daily lives in London from the perspective of their physical activity and body shape.

The detailed description of each of the methods and analysis protocols employed in this chapter adds to the ability of my study to generate meaningful, useful and academically reliable findings. Throughout this process, however, the children themselves are kept at the heart of the research, as the overall aim remains the politically motivated quest to aid the creation of a healthier environment for young Londoners.

Chapter 5: Quantitative Spatial Epidemiology

I. Chapter introduction

The first, quantitative stage of my explanatory sequential mixed-methods research consisted of a three-step spatial epidemiological study, combining data visualisation, exploratory cartographic and statistical analyses, and formal data modelling to investigate the objective built environmental impact on the physical activity and body composition of London primary schoolchildren. In three sections, this chapter describes the results of each of these consecutive steps of the data analysis protocol, jointly providing an answer to the central quantitative research question:

> *"Controlling for potential confounders, are rates of childhood overweight and obesity in London primary schoolchildren spatially and statistically associated with a predefined set of built environmental characteristics, selected based on an extensive literature review, that foster or hinder their extracurricular physical activity?"*

The findings from the cartography and statistics are to be complemented with the results from the second, qualitative stage of the research described in the next chapter. The integration of both then provides a comprehensive understanding of the role played by the built environment in determining London primary schoolchildren's levels of physical activity and excess weight.

II. Step 1 – Data visualization and descriptive statistics

a. Introduction to data visualisation and descriptive statistics

An answer to the geospatial component of the central quantitative research question can be formulated through GIS and cartography, which have become ever more pivotal in Public Health research to enable a deeper comprehension of spatiotemporal disparities in health and disease across populations (Musa et al. 2013). Therefore, also in this doctoral study, maps were produced and interpreted, forming the backbone of such essential spatial analyses. In this first step of the spatial epidemiological research protocol, the variables relating to the body composition, physical activity and built environments of the SLIC children, as well as potential confounders, are visualised through cartography. The description of spatial patterns that can be distinguished from the resulting maps is then supported by descriptive statistics.

Together, the cartography and descriptive statistics provide an insight into the composition of the SLIC sample, and the multitude of environments in which the included London schoolchildren reside, play, commute and attend school. The comparison of the discerned spatial patterns between maps and the discussion of their interrelations follows in the second step of the data analysis protocol, supported by exploratory statistics, allowing the binary associations between variables unveiled by the cartography to be quantified.

b. Retained sample and cartographic visualisation

The spatial structure of the SLIC dataset is investigated by mapping the built environmental characteristics of participants' home and school neighbourhoods, conceptualized as their unique spatialities, alongside the distribution of their body composition, activity levels and potential confounding variables. Where possible, variables are plotted against a background representative of the total population of London primary schoolchildren. The mapmaking, resulting in choropleth and dot maps, and associated cartographic analyses were performed in ArcMap 10.5.1. Participants were excluded from the analyses if anthropometric, activity or neighbourhood deprivation data were missing, or if they were judged not to be healthy at the time of data collection. For the initial sample of 2,171 primary schoolchildren aged five to eleven, attending thirteen schools in London, those data were available for 1,889 healthy SLIC children, 87.0% of the total sample. This group was thus retained for the cartographic and statistical analyses.

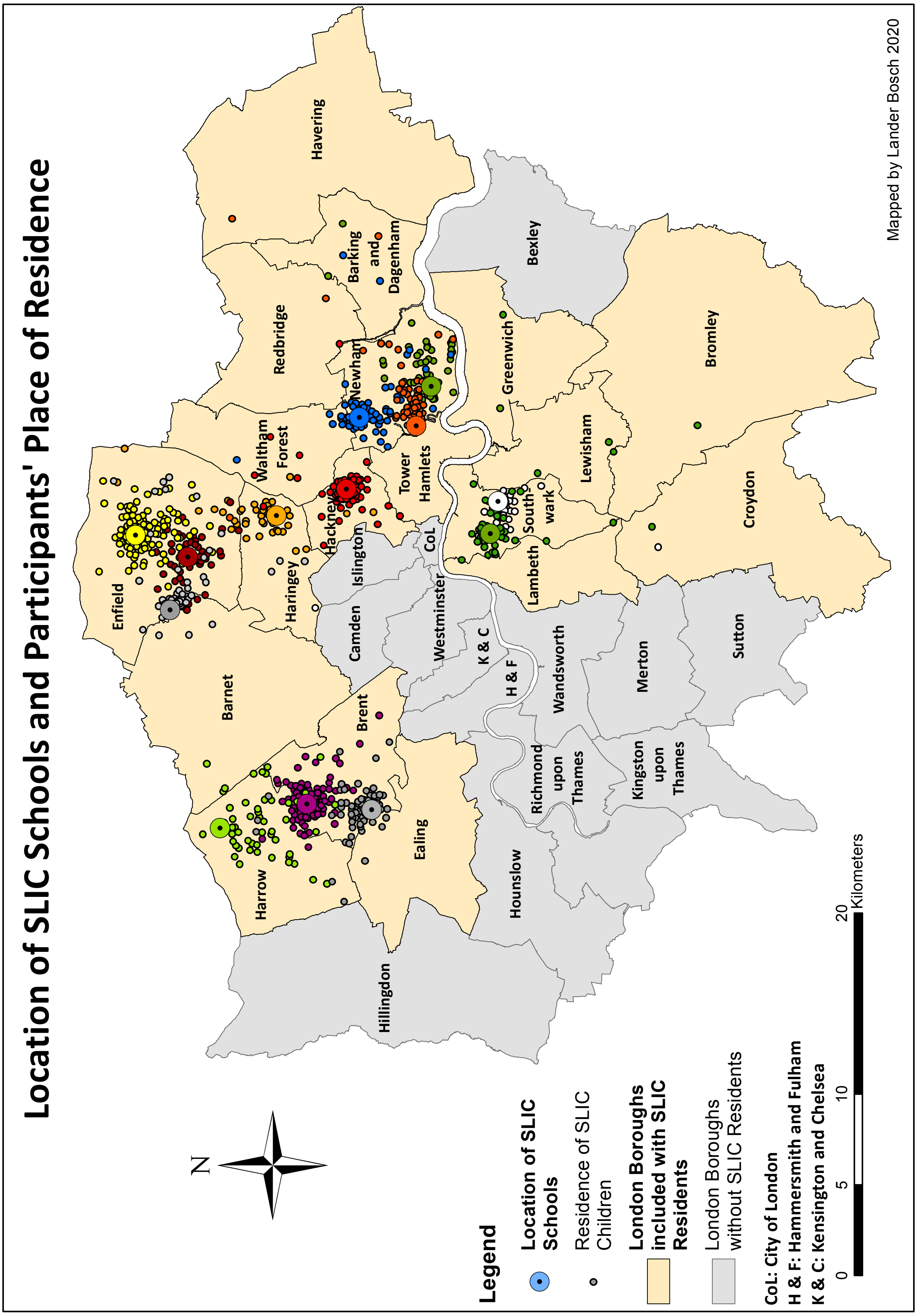
The sizable scope of the retained sample – 1,889 individual primary schoolchildren scattered over the vast expanse of Greater London – makes multi-layered maps, showing multiple variables on the same cartographic frame, highly unclear and unintelligible. Hence, several thematic maps were designed, each covering one aspect of children's weight status, physical activity, and built or socioeconomic environment, which can be placed alongside each other in search of pairwise spatial associations. These issues associated with large-scale mapping demonstrate the added value of cartographic analyses on smaller spatial scales. A closer look at disaggregated, local data can help to further elucidate the specific, underlying mechanisms that may prevent children from reaching their best possible health in specific neighbourhoods (Caldeira et al. 2018). Helpfully, the mixed-methods research design provides the opportunity to zoom in on the scale of the life-worlds and spatialities of the individual children taking part in the go-along interviews in a set of schools, presented in the next chapter.

c. Results & discussion: cartography and descriptive statistics for the SLIC sample and environmental variables

Maps are grouped by thematic area, and their interpretation substantiated by the relevant descriptive statistics, prior to their comparison and joint discussion in the second step of the research protocol. In first instance, a general overview of the place of residence of SLIC children and the location of the school they attend is provided. Secondly, the distribution of participants' body composition across London is shown, followed by their respective levels of physical activity. Fourthly, the built environmental variables included in the statistical analyses are mapped. Next, confounders that have a strong spatial component are visualised. Finally, in direct relation to the cartographic analyses and as highlighted in the methodology, subjects living in closer proximity to each other are likely to be exposed to more similar environmental and socioeconomic conditions in comparison to those living further away. Spatial autocorrelation statistics are therefore calculated to examine the extent to which clustering of observations, potentially violating their independence, occurs. Full data source and copyright information for the cartography can be found in the methods chapter (chapter 4).

i. The location of SLIC schools and participants' place of residence

Map 1 depicts the 824 unique centroids of the home Output Areas of the 1,889 SLIC children retained for the cartographic and statistical analyses. *Table 1* shows the number and share of participants by school ranked by their median commuting distance along the shortest route. Due to the presence of several outliers potentially skewing the findings, the median commuting distance is considered to be more representative than the average.



Map 1: Location of SLIC Schools and Participants' Place of Residence (© see methodology)

School Borough (Colour)	Inner/Outer London	Number (%) of SLIC Participants	Median Route School Distance (m)
Hackney (Red)	Inner	181 (9.6%)	625
Southwark East (White)	Inner	85 (4.5%)	699
Southwark West (Green)	Inner	139 (7.4%)	890
Brent South (Grey)	Outer	249 (13.2%)	1,098
Enfield South (Red)	Outer	130 (6.9%)	1,128
Brent North (Purple)	Outer	280 (14.8%)	1,205
Newham North (Blue)	Inner	97 (5.1%)	1,347
Haringey (Orange)	Inner	63 (3.3%)	1,413
Newham West (Orange)	Inner	150 (7.9%)	1,628
Enfield North (Yellow)	Outer	209 (11.1%)	1,640
Enfield West (Grey)	Outer	120 (6.4%)	1,642
Newham South (Green)	Inner	105 (5.5%)	1,696
Harrow (Green)	Outer	81 (4.3%)	2,972
Total		**1,889**	**1,264**

Table 1: SLIC participants per school, ranked by median commuting distance

SLIC children, whose home Output Area centroids are coloured according to the school they attended, primarily resided in the Borough where their school was located. Three SLIC schools were situated in the Boroughs of Newham and Enfield, two in Southwark and Brent, and one each in Haringey, Hackney and Harrow. Whilst most participants lived and attended school in Northwest, North and East London, the geographical spread of the studied sample of SLIC children and schools ensures the inclusion of a wide spatial range of research environments, covering all sub-regions of London. Commuting distances tended to be larger for SLIC children living and attending school in Outer London. The three schools with the shortest commuting distances were all situated close to the city centre, in Southwark and Hackney, whereas two out of three schools with the longest commuting distances were located in Enfield and Harrow, in Outer London. This smaller commuting distance to schools closer to the city centre is not surprising, given both the population and school density in Inner London are nearly three times as high as in Outer London (GLA 2018a, Department for Education 2019).

ii. Body composition of SLIC and London primary schoolchildren

As discussed in the methodology, the disentanglement of body mass into its fat and fat-free components is crucial to obtain correct and robust findings on the human ecology of childhood overweight and obesity. Hence, *maps 2, 3* and *4* depict the spatial distribution of the weight status of SLIC children, not only as measured by the commonly used BMI, but also by their FMI and FFMI, as calculated in this study. The descriptive body composition statistics for the sample are summarised in *table 2*. SLIC Children's weight status category is shown by coloured dots placed on the centroid of their Output Area of residence.

As body composition is rarely disentangled and this information is more labour-intensive and complex to collect, London-wide data are only available for BMI. Population-level data on fat and muscle mass are structurally lacking. Therefore, the background to all three maps is the percentage of overweight and obese Year 6 schoolchildren in London measured by their BMI at the time of SLIC data collection (2010-2013), plotted on the finest spatial scale for which data are available: the MSOA. These data for London primary schoolchildren aged ten to eleven represented on the maps match BMI trends at younger ages (Department of Health 2020b).

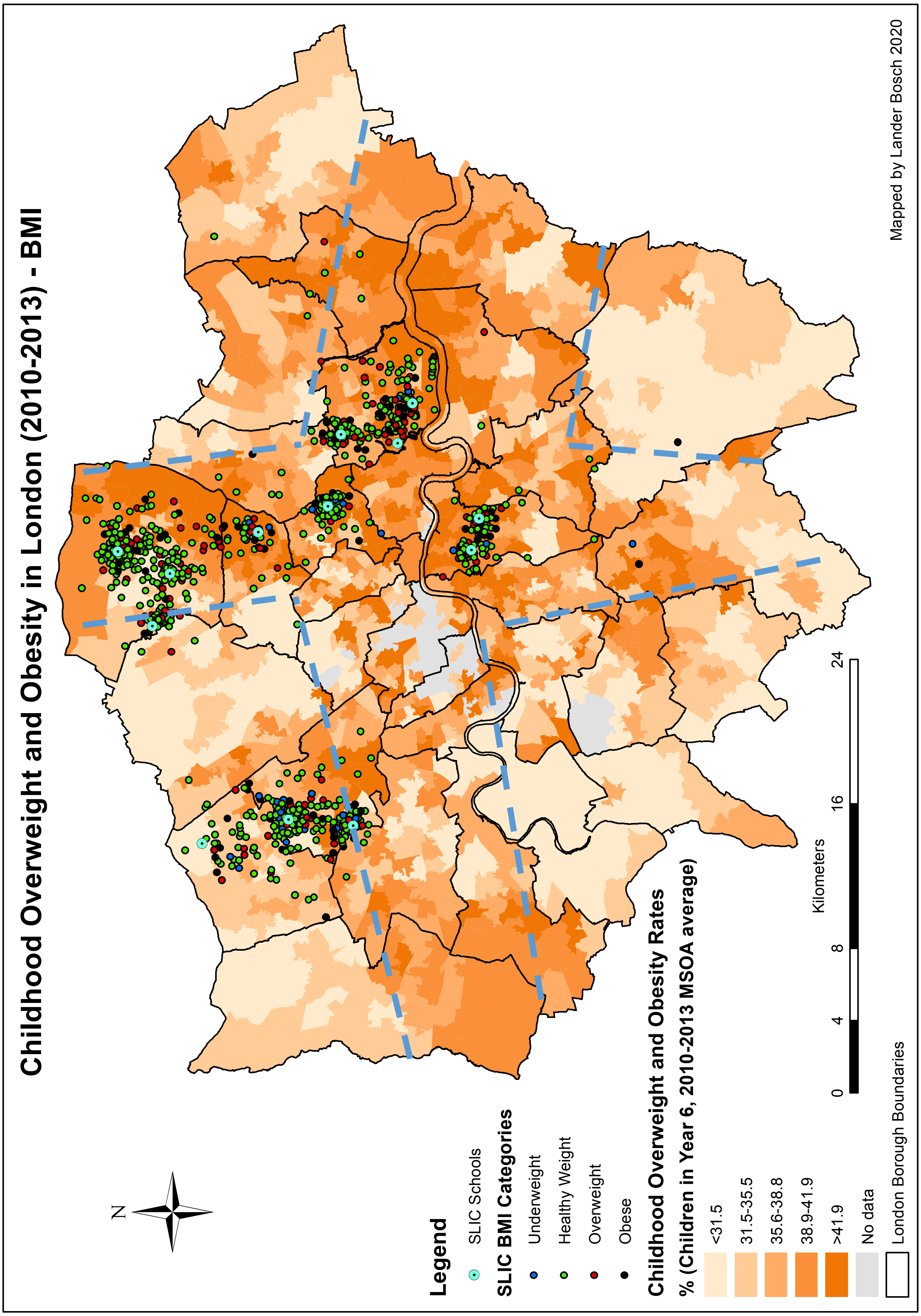
Body composition of SLIC children included in the cartographic-statistical analyses		
Variable	**Number of SLIC children**	**Percentage (%)**
Age- and sex-adjusted BMI z-score		
$<5^{th}$ percentile, 'underweight'	75	**4.0**
5^{th}-85^{th} percentile, 'healthy weight'	1,227	**64.9**
85^{th}-95^{th} percentile, 'overweight'	234	**12.4**
$>95^{th}$ percentile, 'obese'	353	**18.7**
ln(FMI) z-score		
$<5^{th}$ percentile	56	**3.0**
5^{th}-85^{th} percentile	1,546	**81.8**
85^{th}-95^{th} percentile	172	**9.1**
$>95^{th}$ percentile	115	**6.1**
FFMI z-score		
$<5^{th}$ percentile	61	**3.2**
5^{th}-85^{th} percentile	1,564	**82.8**
85^{th}-95^{th} percentile	167	**8.9**
$>95^{th}$ percentile	97	**5.1**

Table 2: Body composition of SLIC children included in the cartographic-statistical analyses

For 18.7% of SLIC children, their age- and sex-adjusted BMI z-score percentile placed them in the obese category, with another 12.4% falling in the overweight category. 9.1% had an FMI score between the 85^{th} and 95^{th} percentiles, and another 6.1% scored above the 95^{th} percentile. For FFMI, similar percentages to the FMI results are obtained.

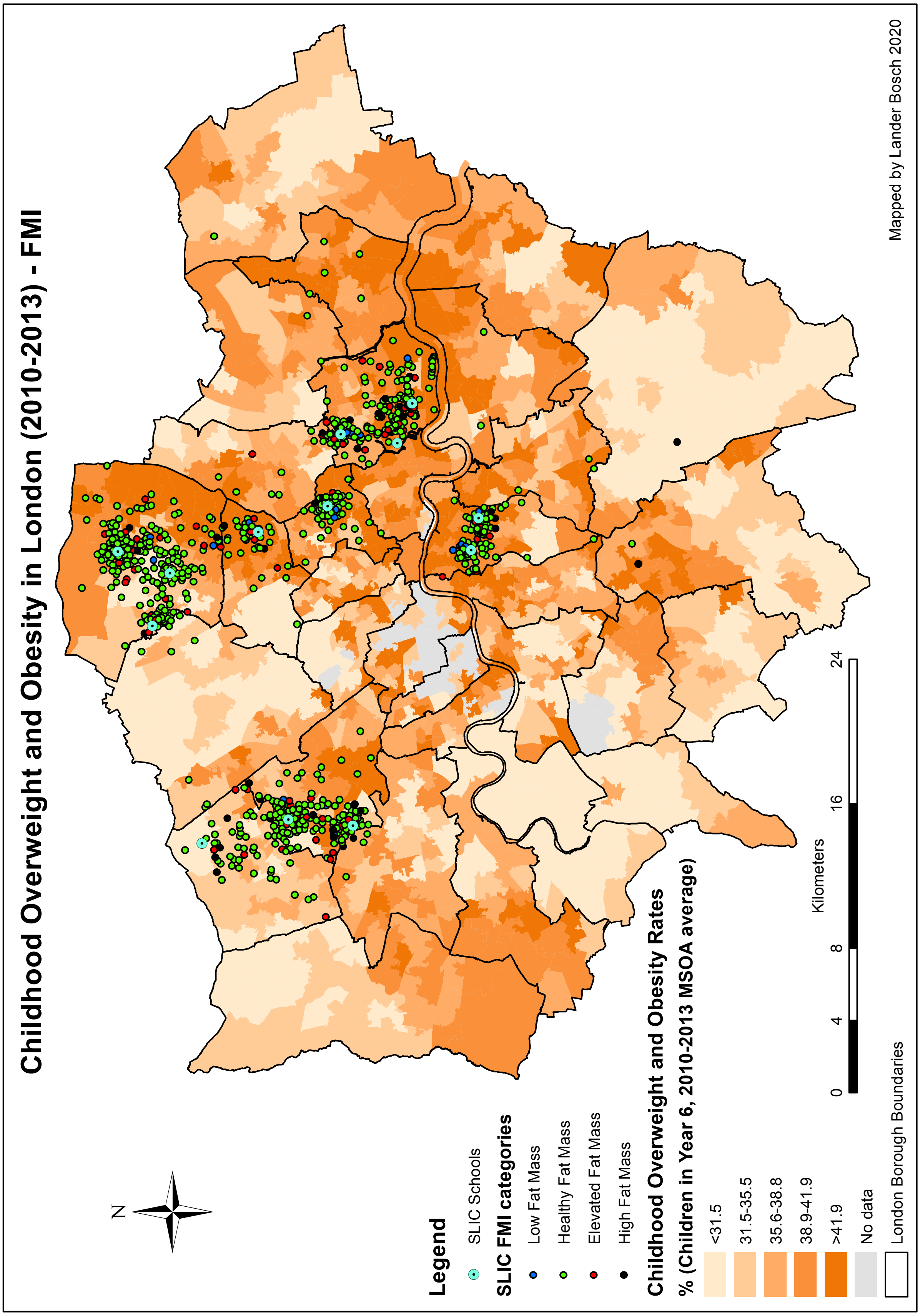
Spatially, two axes of high BMI levels can be observed, running quasi-perpendicularly through the heart of the capital. These are indicated by the blue dashed lines on *map 2*. The vast majority of SLIC children resided within the axes' boundaries, and, analogously, elevated BMI levels could be observed among those children. Particularly around schools in Newham, southern Brent and eastern Southwark, elevated BMIs appear to be highly prevalent. On the other hand, pupils living in the northern part of Brent seem to be confronted with higher levels of underweight.

By separating FMI from FFMI, the potentially differing role of fat and muscle mass can be studied (*Maps 3* and *4*). Focusing on these components individually, inter-school differences appear to be reduced. Nonetheless, schools in Newham, southern Brent and eastern Southwark still had a significant share of pupils belonging to the highest fat mass categories. However, the fat-free mass of the children living in Newham and Southwark was also higher compared to those residing in other parts of London. This finding for body composition suggests that the labelling of children living in these areas as overweight or obese based solely on BMI leads to potential misclassifications, as their strongly developed muscle mass contributed to their higher total body weight. On the other hand, the FMI pattern of children residing in Brent does not differ strongly from that of other SLIC children, though the former appear to be faced with less strong muscle development. This engenders a potential underestimation of childhood overweight and obesity in these areas when BMI is used, as fat, and not fat-free mass, is the key body composition component adversely impacting health.

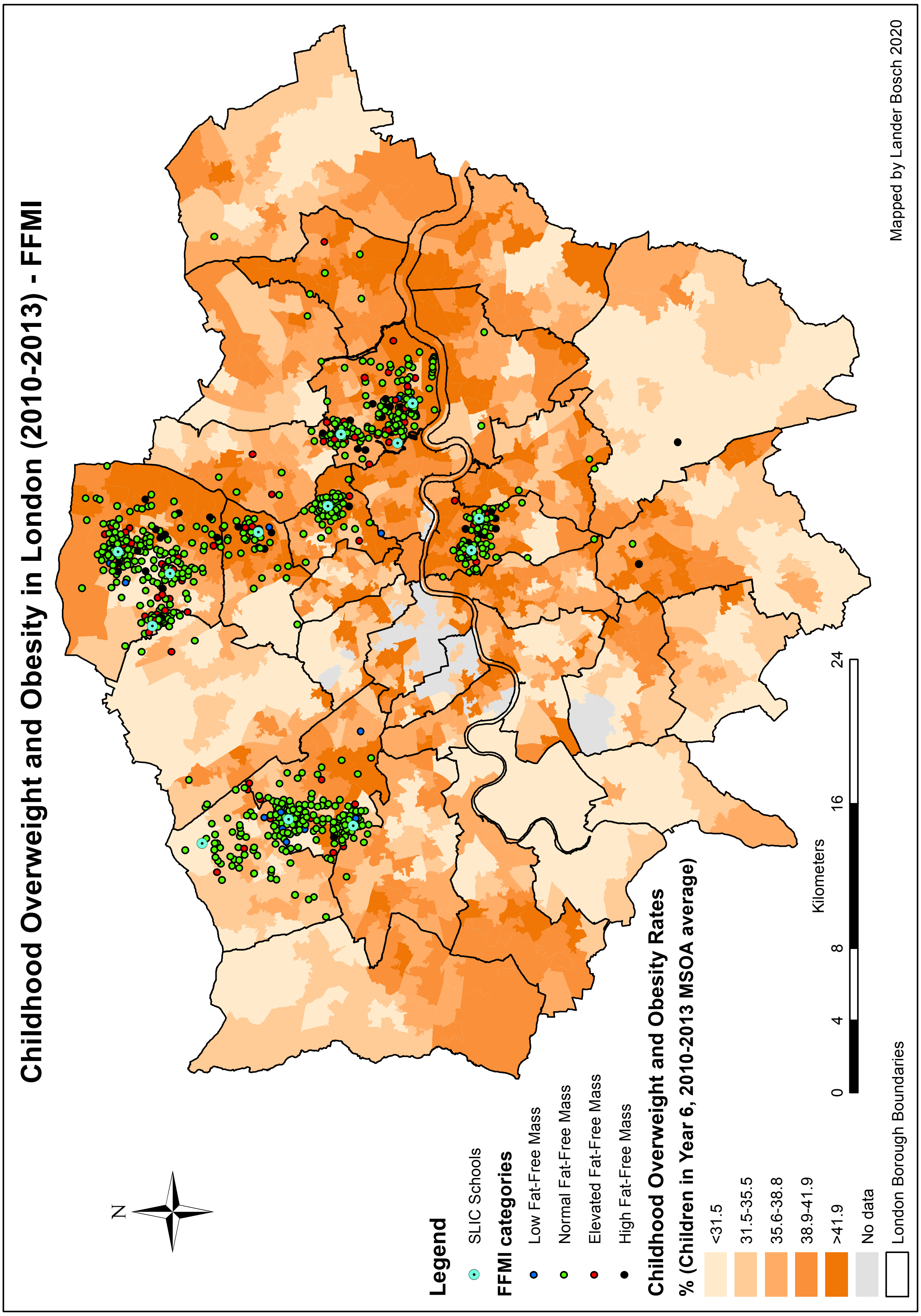


Map 2: BMI categories for SLIC children and London-wide childhood overweight and obesity rates measured by BMI

(© see methodology)



Map 3: FMI categories for SLIC children and London-wide childhood overweight and obesity rates measured by BMI (© see methodology)



Map 4: FFMI categories for SLIC children and London-wide childhood overweight and obesity rates measured by BMI (© see methodology)

iii. Out-of-school physical activity of SLIC and London primary schoolchildren

The role of physical activity as a potential mediator in the relationship between the built environment and children's levels of overweight and obesity should also be spatially explored. In analogy to body composition, the literature review demonstrated the importance of breaking down this overall variable into its prime components in order to arrive at a better understanding of its multifaceted impacts. Hence, the key contributors to children's extracurricular physical activity that form the focus of this study are presented separately. The dominant mode of commuting to school for the SLIC children is shown in *map 5*, followed by their weekly frequency of engaging in sports and exercise in *map 6*. The associated descriptive statistics are presented in *table 3*.

As mentioned in the methods chapter (chapter 4), contrasting with the detailed SLIC information, very limited information is available about the London-wide out-of-school physical activity of pupils. This severely hampers a more universal framing of the activity of SLIC children in a city-wide context. Only one child activity-related variable is available in the London Datastore for the relevant time period (2010-2013): the share of pupils engaging in over two hours of weekly PE and sports, recorded at the borough level (Department for Education 2014). Though this measure focuses primarily on physical activity as part of the school curriculum, it could contribute to the understanding of the spatial distribution of commuting and engagement in sports and exercise observed for participants of the SLIC study. Hence, this measure is plotted as background to the maps.

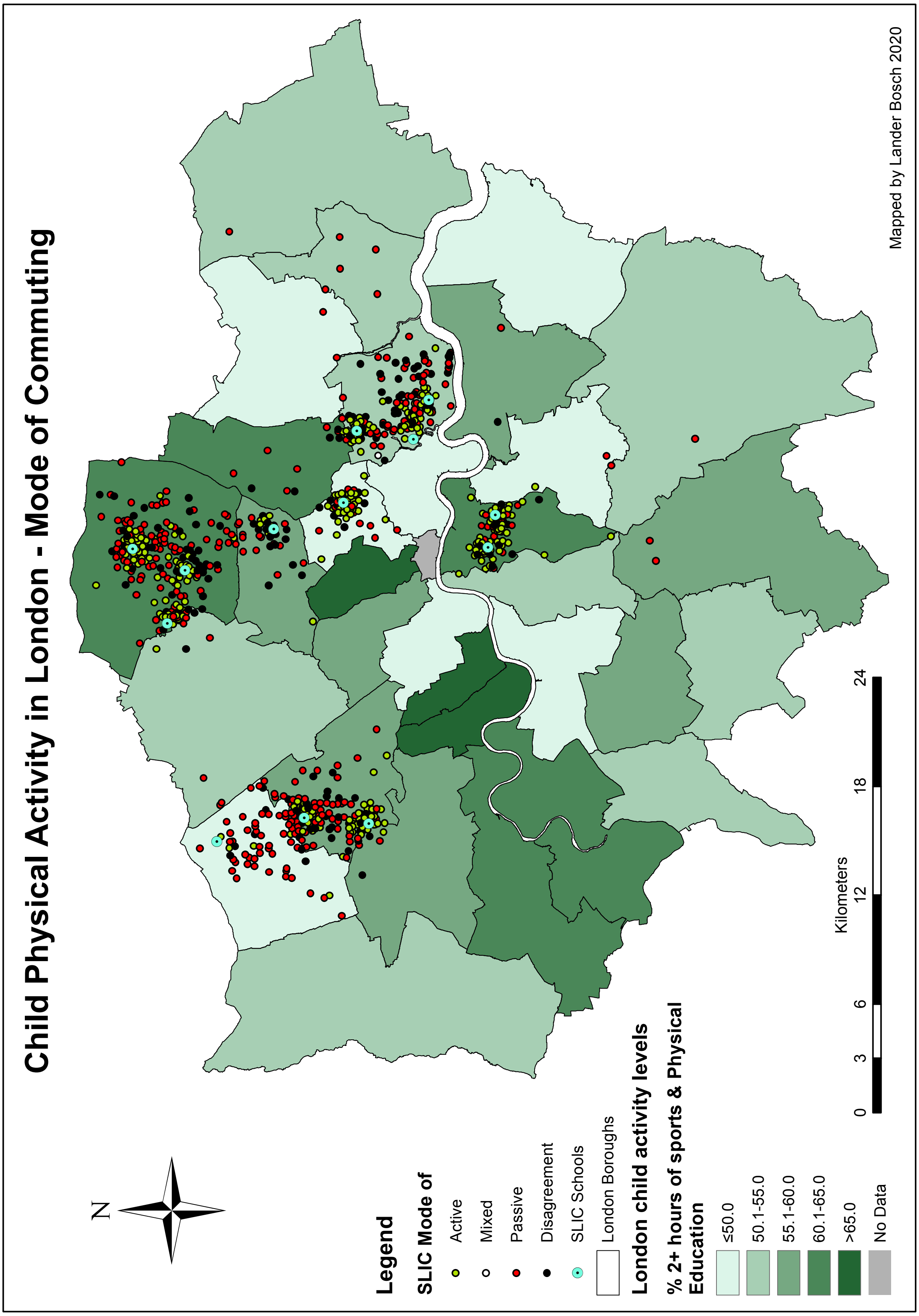
Nearly half of the SLIC included children and their parents indicated that they commuted actively to school. Of this group of 883 children using active modes of transport, only ten (1.1%) specified that they predominantly cycled to school. All others mainly commuted on foot. Due to this small number of children using a bicycle, all pupils walking or cycling to school are merged into one, overarching group of active commuters. One-third of participants said to predominantly use passive means of transport. In one out of five cases, parent and child reports are inconsistent (21.1% of responses). Due to its sizeable share of the total sample, this disagreement group has been retained as a separate category in the statistical models, together with the small group of pupils using mixed modes of commuting. The results for self-reported extracurricular physical activity suggest that 44.1% of SLIC children engaged in sports every day, with only 1.4% being completely inactive.

Physical activity of SLIC children included in the cartographic-statistical analyses		
Variable	**Number of SLIC children**	**Percentage (%)**
Dominant mode of commuting		
Active	883	**46.7**
Passive	598	**31.7**
Mixed & Disagreement	408	**21.6**
General Sports & Exercise Frequency		
Never	26	**1.4**
Less than weekly	73	**3.8**
Weekly	476	**25.2**
Most days	481	**25.5**
Daily	833	**44.1**

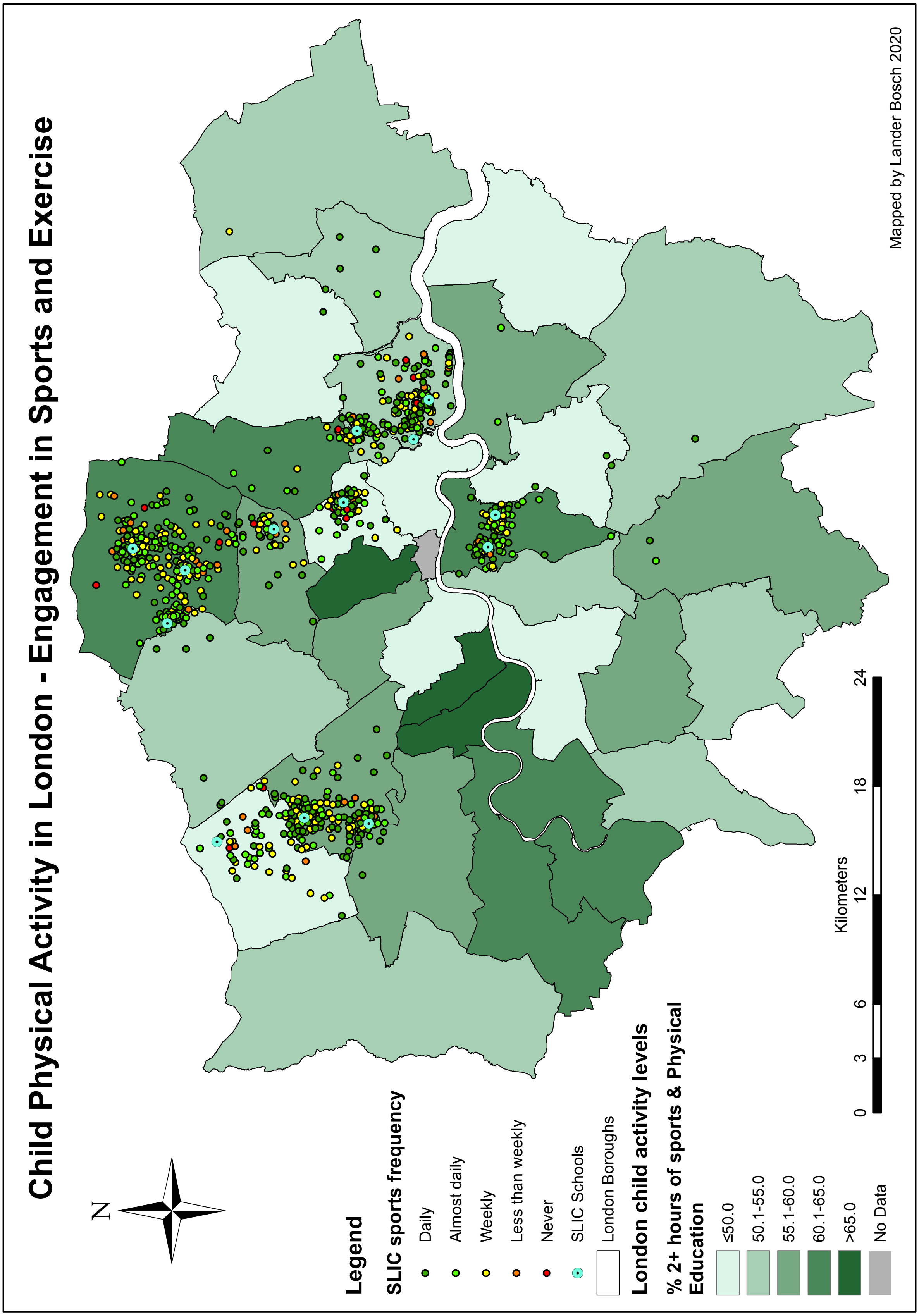
Table 3: Physical activity of SLIC children included in the cartographic-statistical analyses

No consistent activity patterns emerge at the Borough level when examining the background variable of the maps, most likely due to the coarse aggregation of these data in large, administrative spatial units.

The visualisation of the disentangled extracurricular physical activity data for SLIC children is far more revealing. On the one hand, SLIC children living closer to school appeared to be more likely to actively commute to school in comparison to those living further away, with participants residing in Northwest London having an overall higher propensity to be passive commuters. The large share of disagreement on the dominant mode of commuting between parents and children also stands out from this cartographic representation. This illustrates the potential bias present in self-reported physical activity data. On the other hand, participants living in North London appeared to participate in sports and exercise less frequently compared to SLIC children who lived elsewhere in the capital.



Map 5: SLIC children's commuting mode and London-wide child rates of sports and PE within and beyond the curriculum (© see methodology)



Map 6: SLIC children's sports frequency and London-wide child rates of sports and PE within and beyond the curriculum

(© see methodology)

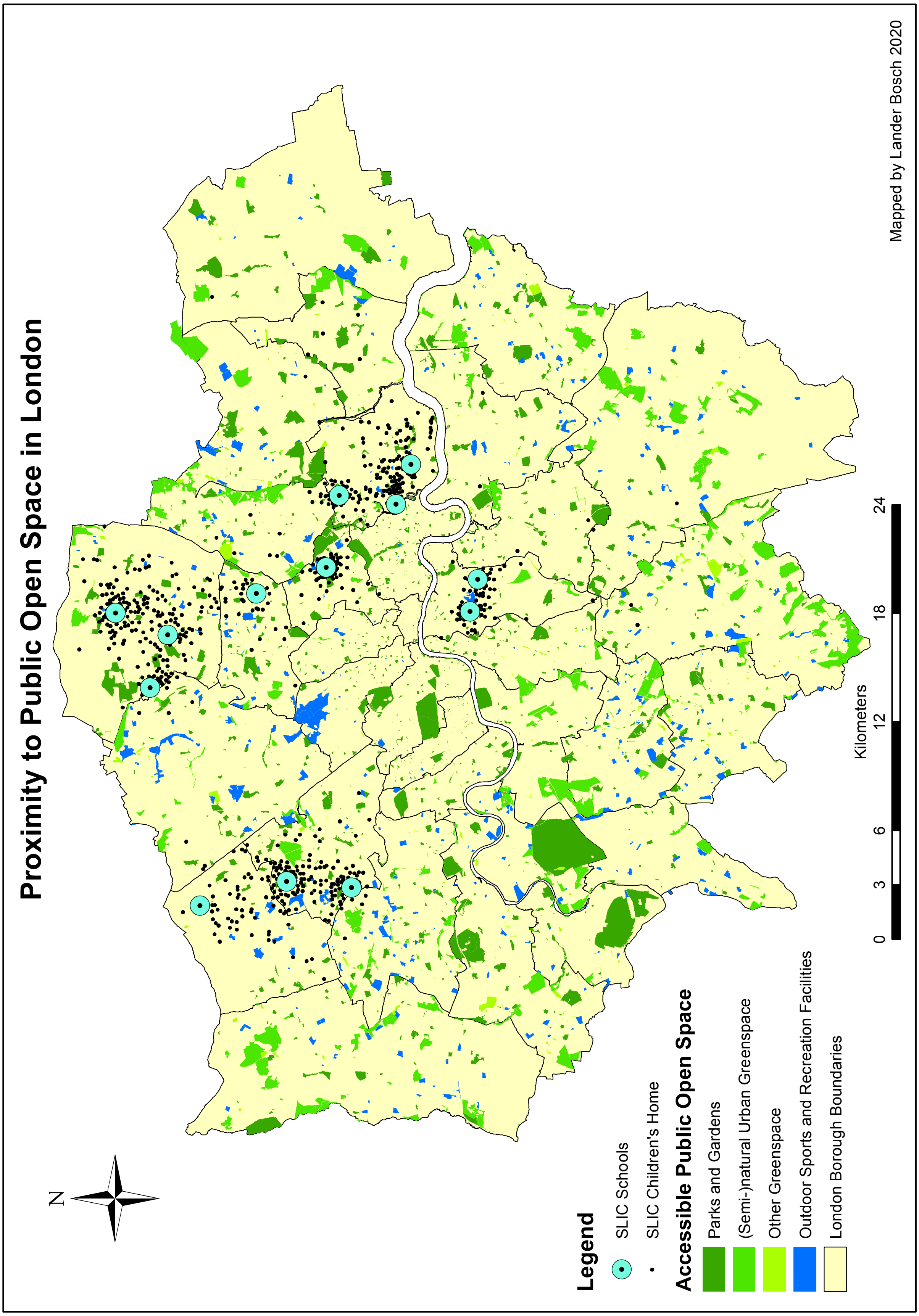
iv. The built environments of SLIC and London primary schoolchildren

Six objectively measurable built environmental characteristics were identified in the literature review, evidenced to incite or deter physical activity or weight gain, or requiring further exploration to reach an improved understanding of their potential role as drivers of, or barriers to, activity and overweight among primary schoolchildren. Each of these variables is mapped separately. Whereas the proximity of SLIC children's homes to school has already been visualised above in *map 1*, the location of public greenspace and facilities for participants' engagement in sports and recreation is shown in *map 7.* Traffic and personal risk across London are mapped in *maps 8* and *9*. *Map 10* then captures the spatial disparities in air pollution. Next, the walkability of the home and school neighbourhoods of SLIC children and across London is shown in *map 11*. Finally, *map 12* visualises the density of convenience stores children in London were exposed to in the outdoor public space.

The descriptive statistics for the proximity to school, parks and public gardens, and sports and recreation facilities are presented in *table 4*. Those for the safety, pollution, walkability and the foodscape variables are jointly displayed in *table 5.* For the latter set of built environmental characteristics, the value recorded for the administrative unit in which SLIC children resided is included, alongside the average and extreme 'worst case' value observed along the shortest commuting route to school.

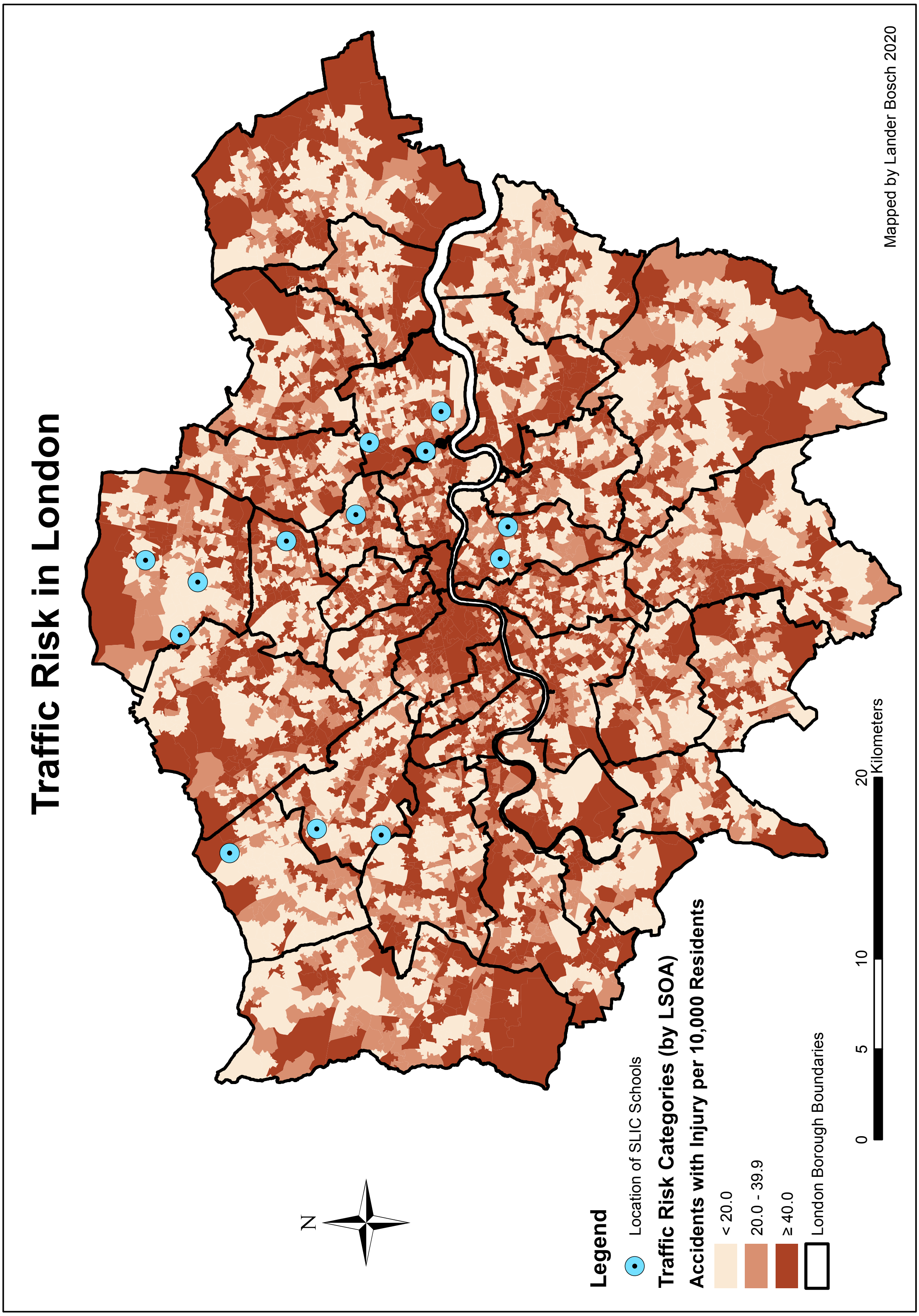
Proximity to neighbourhood facilities for SLIC children						
Proximity along shortest route	**School (N)**	**School (%)**	**Park or Public Garden (N)**	**Park or Public Garden (%)**	**Sports or Recreation Facility (N)**	**Sports or Recreation Facility (%)**
Distance (m)						
< 500	190	**10.1**	446	**23.6**	103	**5.5**
500 – 999	457	**24.2**	849	**44.9**	468	**24.8**
1,000 – 1,499	454	**24.0**	468	**24.8**	464	**24.5**
≥ 1,500	788	**41.7**	126	**6.7**	854	**45.2**

Table 4: Proximity to neighbourhood facilities for SLIC children

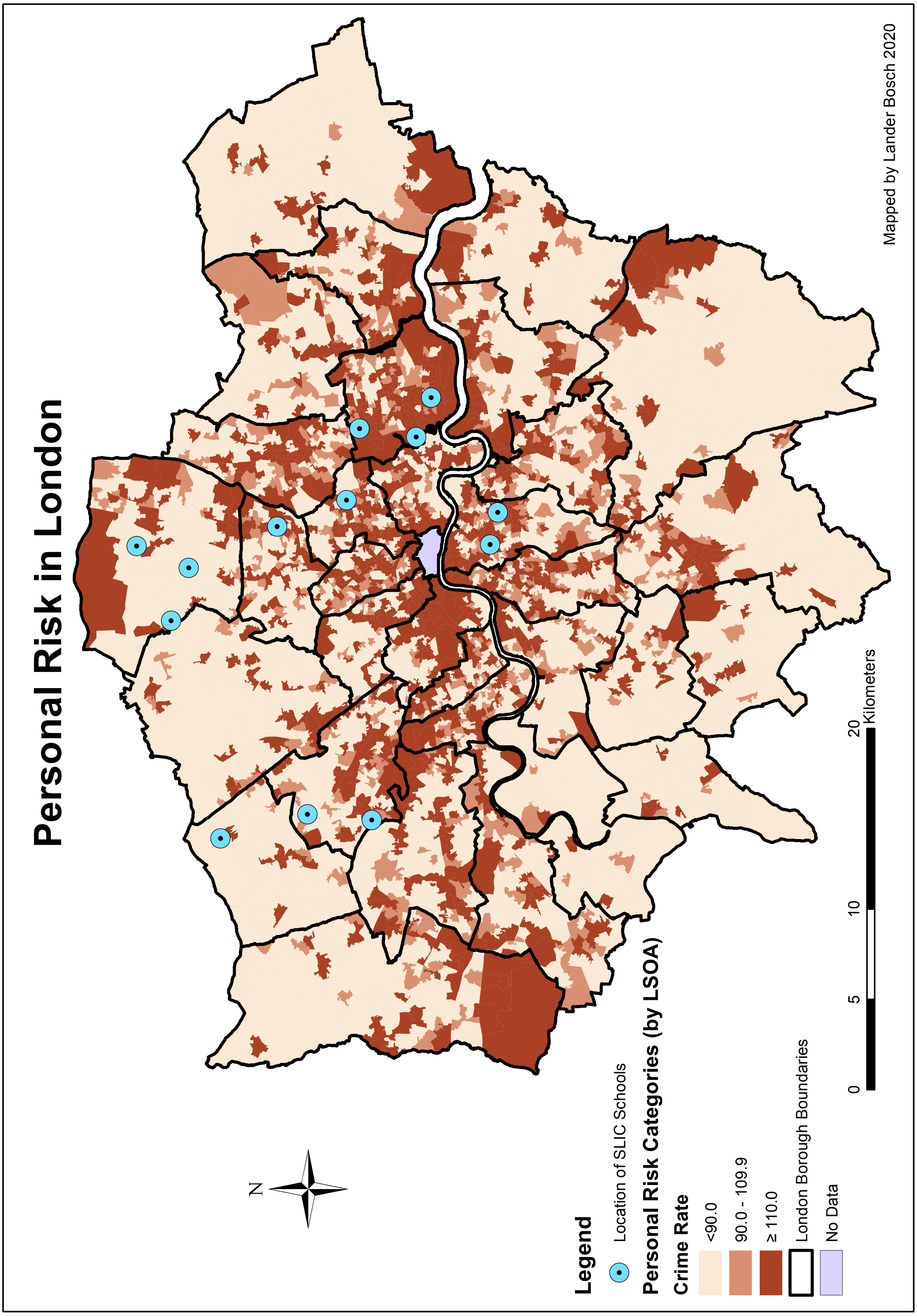


Map 7: Proximity to parks, public gardens and sports and recreation facilities in London

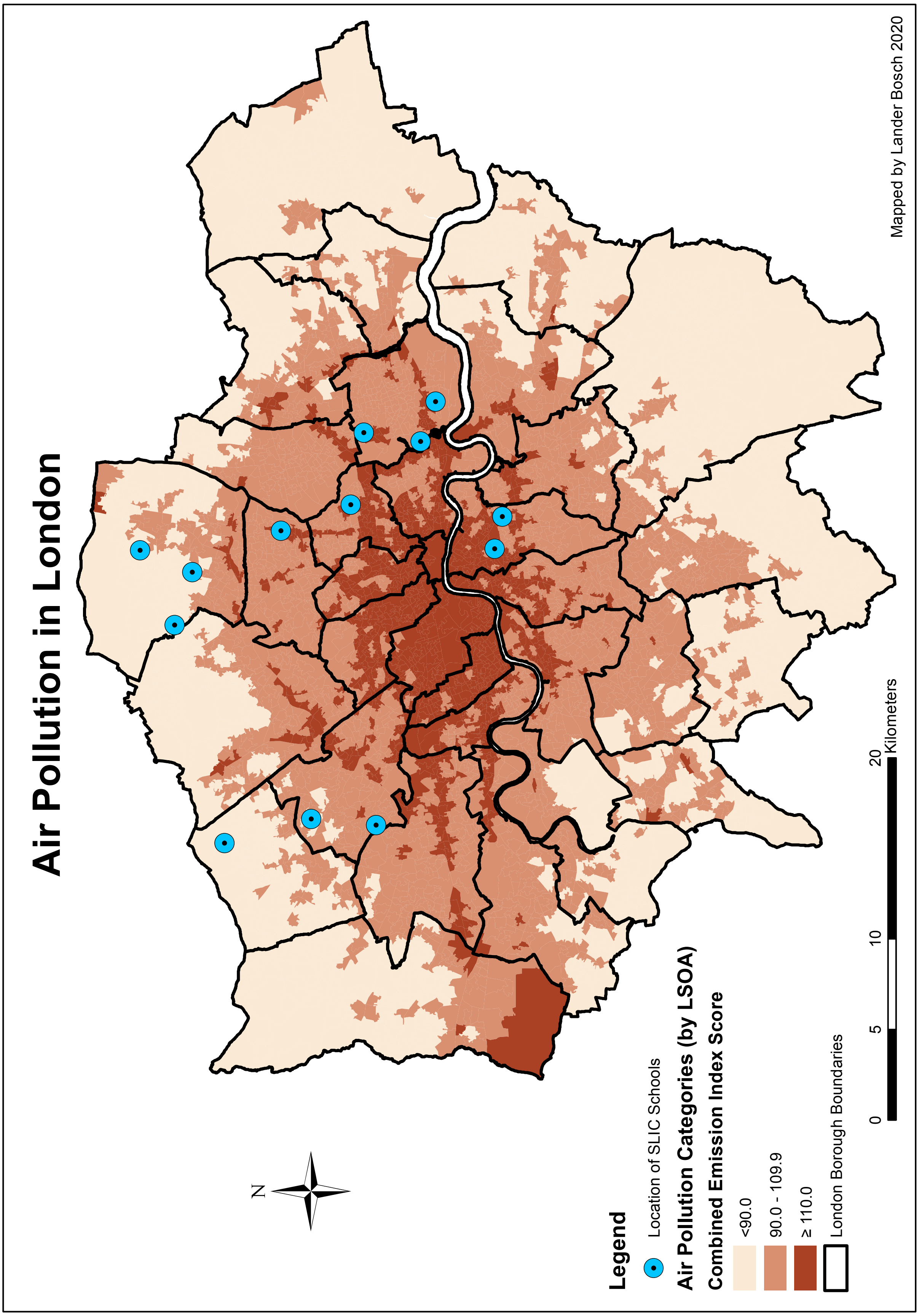
(© see methodology)



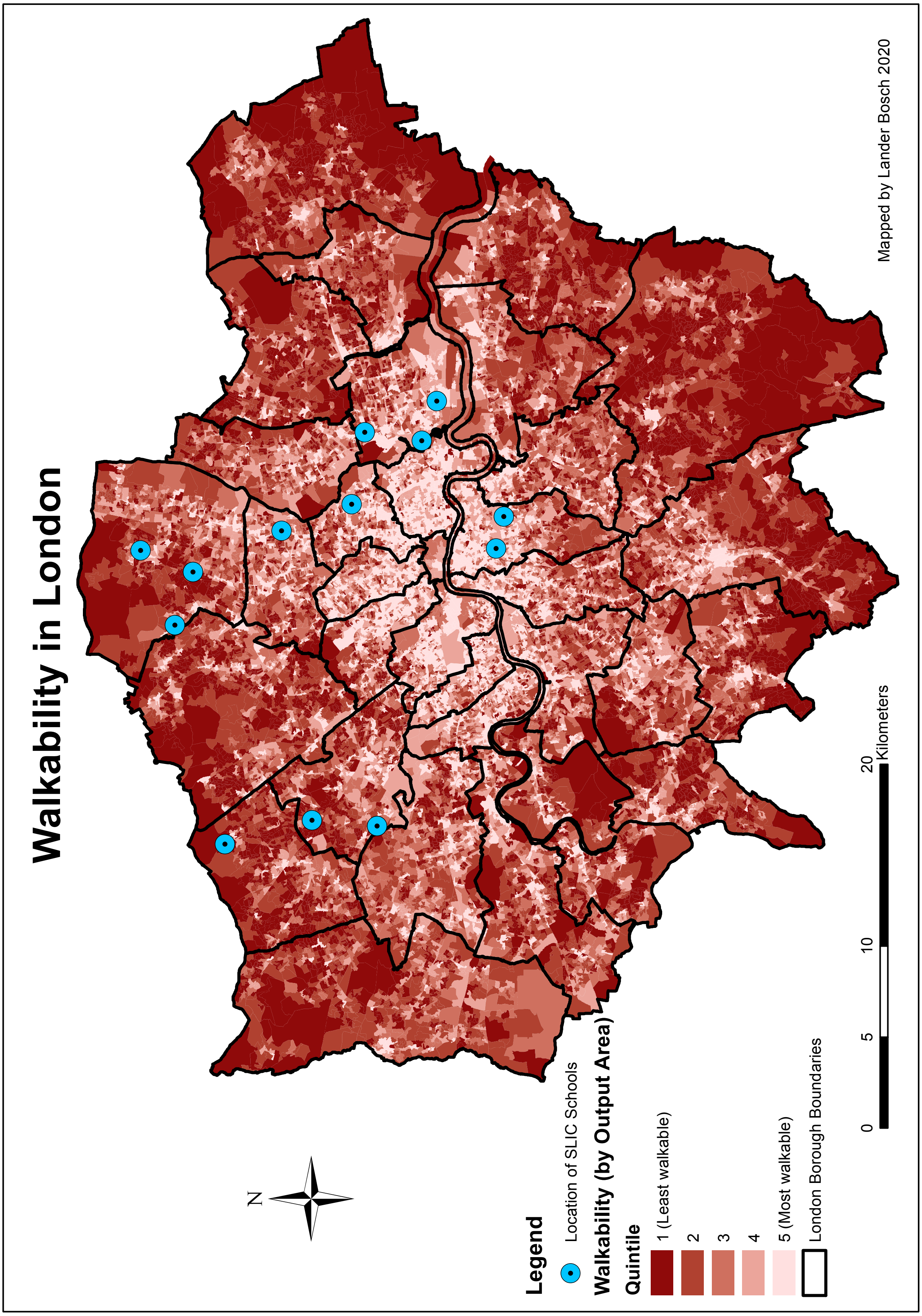
Map 8: Traffic risk in London (© see methodology)



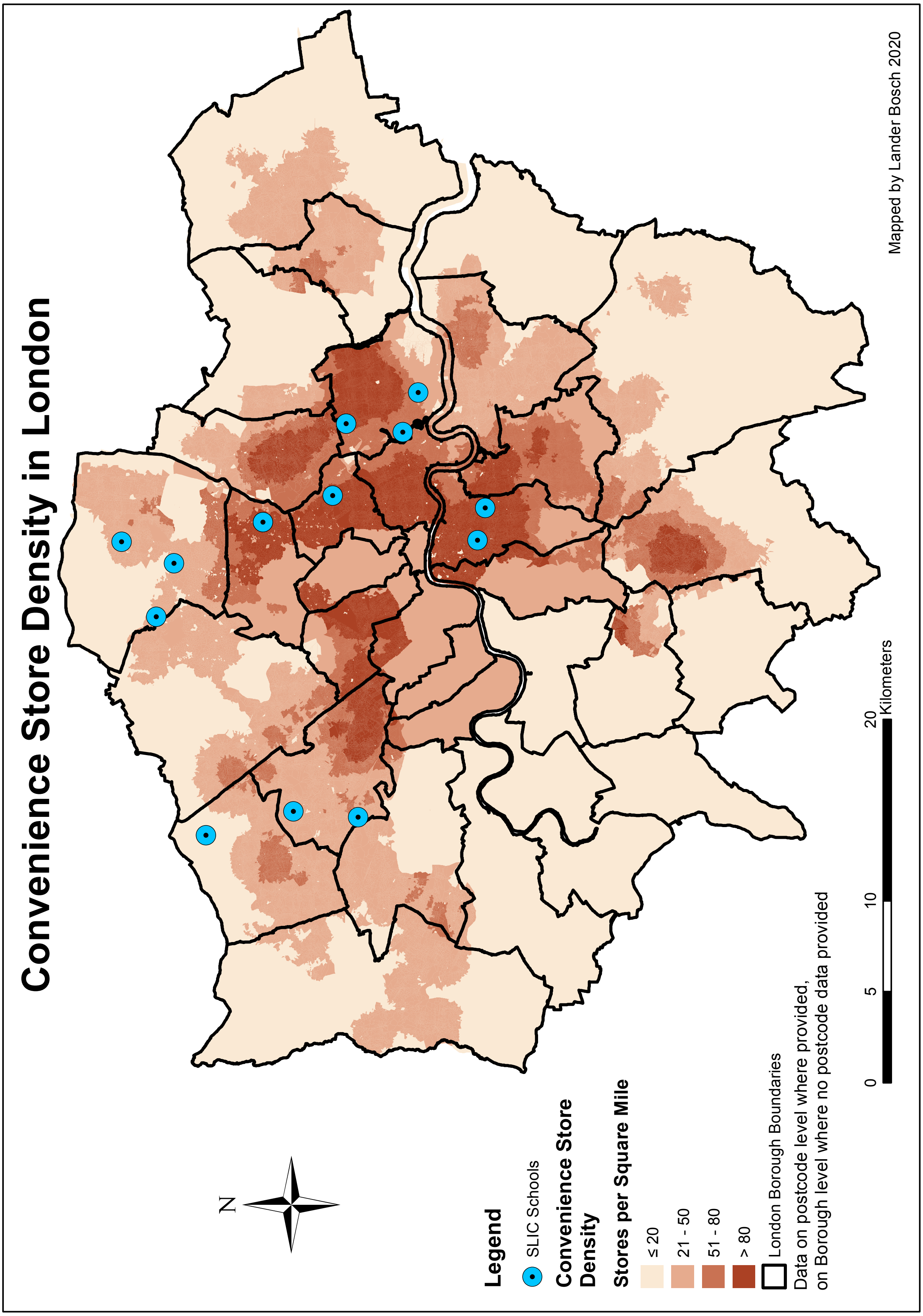
Map 9: Personal risk in London (© see methodology)



Map 10: Air pollution in London (© see methodology)



Map 11: Walkability in London (© see methodology)



Map 12: Convenience story density in London (© see methodology)

Safety, pollution, walkability and the foodscape for SLIC children			
Variable	**Measures**	**Number of SLIC children**	**Percentage (%)**
Traffic Risk	***Accident rate/10^4 inhabitants in home LSOA***		
	<20	814	**43.1**
	20-40	510	**27.0**
	> 40	466	**24.7**
	Unknown	99	**5.2**
	Average accident rate/10^4 inhabitants along commute		
	<20	591	**31.3**
	20-40	940	**49.8**
	> 40	358	**18.9**
	Maximum accident rate/10^4 inhabitants along commute		
	<20	151	**8.0**
	20-40	557	**29.5**
	> 40	1,181	**62.5**
Personal Risk	***Crime rate in home LSOA***		
	<90	999	**52.8**
	90-110	207	**11.0**
	> 110	583	**30.9**
	Unknown	100	**5.3**
	Average crime rate along commute		
	<90	919	**48.7**
	90-110	193	**10.2**
	> 110	777	**41.1**
	Maximum crime rate along commute		
	<90	423	**22.4**
	90-110	161	**8.5**
	> 110	1,305	**69.1**
Air Pollution	***Average Combined Emission Index in home LSOA***		
	<90	455	**24.1**
	90-110	1,020	**54.0**
	> 110	314	**16.6**
	Unknown	100	**5.3**
	Average Combined Emission Index along commute		
	<90	626	**33.1**
	90-110	975	**51.6**
	> 110	288	**15.3**
	Maximum Combined Emission Index along commute		
	<90	212	**11.2**
	90-110	983	**52.0**
	> 110	694	**36.8**
Walkability	***Walkability Index quintile in home Output Area***		
	1 (least walkable)	462	**24.5**
	2	469	**24.8**
	3	296	**15.7**
	4	375	**19.8**
	5 (Most walkable)	287	**15.2**

Walkability	***Average Walkability Index quintile along commute***		
	1 (least walkable)	182	**9.6**
	2	545	**28.9**
	3	544	**28.8**
	4	526	**27.8**
	5 (Most walkable)	92	**4.9**
	Minimum Walkability Index quintile along commute		
	1 (least walkable)	1,226	**64.9**
	2	356	**18.8**
	3	221	**11.7**
	4	79	**4.2**
	5 (Most walkable)	7	**0.4**
Foodscape	***Convenience stores/mile^2 around home Postcode Area***		
	≤20	119	**6.3**
	21-50	525	**27.8**
	51-80	932	**49.3**
	> 80	309	**16.4**
	Unknown	4	**0.2**
	Average convenience stores/mile^2 along commute		
	≤20	78	**4.1**
	21-50	1,005	**53.2**
	51-80	226	**12.0**
	> 80	580	**30.7**
	Maximum convenience stores/mile^2 along commute		
	≤20	32	**1.7**
	21-50	761	**40.3**
	51-80	432	**22.9**
	> 80	664	**35.1**

Table 5: Safety, pollution, walkability and the foodscape for SLIC children

The descriptive statistics demonstrate that only one in ten SLIC children resided within 500 metres of school, while for 41.7% of children the shortest commuting distance was over the walkable threshold of 1,500 metres. Parks and gardens are present widely scattered across Greater London, whereas the provision of sports and recreation facilities is visibly scarcer. Hence, participants tended to reside in closer proximity to greenspace. Just under a quarter of included pupils had to travel under 500 metres to the nearest park or public garden, with two-thirds living within one kilometre. In contrast, distances to sports and recreation facilities were considerably larger. Some 70% of SLIC children had to commute a minimum of 1,000 metres to reach this type of public amenity. These facilities were more densely provided, though generally smaller in size, closer to the city centre in comparison to those towards the edges of Outer London Boroughs such as Harrow or Enfield. This implies that, whilst the homes and schools of most SLIC children were situated within walking distance of outdoor facilities where they could freely engage in outdoor, extracurricular physical activity, children in Outer London Boroughs needed to cover larger distances to reach them.

Traffic risk varies strongly across London, though the cartography shows that accident rates are found to be consistently high in the city centre. Children, especially those with longer commuting distances, are thus likely to be exposed to strongly diverging degrees of risk along the way. The descriptive statistics corroborate this observation: while 43.1% of participants lived in an LSOA with less than twenty accidents per 10,000 inhabitants, the average traffic risk along the route to school fell in this lowest category for only one-third of children, compared to 18.9% in the highest category. A sizeable 62.5% of participants were confronted with at least one LSOA segment with the highest level of risk *en route* to school.

Personal risk in London shows a more distinct spatial pattern when mapped. Crime rates are high along quasi-perpendicular axes running from west to east and north to south, converging in Central London. SLIC children residing and attending school towards the edges of the city (in Enfield and Harrow) were thus confronted with lower personal risk than those closer to the centre, with school environments in Haringey, Southwark, Hackney and Newham standing out in a particularly negative sense from a personal safety perspective. 52.8% of the sample lived in an LSOA with a crime rate below 90, in comparison to 30.9% residing in neighbourhoods with significant personal risk, having a crime rate over 110. 48.7% of participants were exposed to low average levels of crime along the commuting route. However, over two-thirds of pupils (69.1%) crossed at least one LSOA in the highest crime rate category on the way to school along the shortest route.

Air pollution shows a distinct radial pattern upon visualisation, with the highest concentrations of airborne toxins found in central London Boroughs. SLIC children living and attending school in Outer London were therefore less exposed to potentially unhealthy environments, as the ambient air quality in their home neighbourhoods was distinctly better in comparison to pollution levels in Inner London. Local pollution hotspots further away from the city centre, often following linear patterns, can be linked to major traffic arteries such as the North and South Circular Roads or, in West London, the presence of Heathrow Airport. The visual evidence supports the inclusion of air pollution metrics that are based on vehicle exhaust as a proxy of traffic density. 15.3% of children faced pollution levels in the highest category on average during their commute. However, over a third of pupils (36.8%) were confronted with a maximum Combined Emission Index score over 110 in at least one administrative unit along the route, with 16.6% of SLIC children residing in a highly polluted LSOA.

Walkability also diminishes from the centre of the city to the outskirts, with local hotspots in the denser urban cores of Outer London Boroughs. Hence, walkability levels around SLIC participants' homes and schools in Newham, Southwark and Hackney were generally higher than those in Haringey, Brent, Enfield or Harrow. Given the components of the composite Walkability Index, this is perhaps not surprising: residential density, street connectivity and land use mix are higher in the city centre compared to the less dense and more suburban residential Boroughs of Outer London. A quarter of children included in the sample lived in an Output Area in the least walkable quintile, whereas 15.2% resided in a highly walkable home neighbourhood. 85.5% of children commuted along roads with an average Walkability Index score in the intermediate second, third or fourth quintiles. However, 64.9% had to cross at least one Output Area in the lowest quintile.

The cartography of the spatial distribution of convenience stores shows a rather patchy pattern. Densities are generally highest towards Central London, with hotspots of outlets across the city. SLIC schools and pupils residing in Southwark, Hackney, Newham and Haringey were therefore exposed to the highest quantities of unhealthy food outlets. For only 4.1% of children, the average density on the way to school fell in the lowest category (≤20 stores/mile^2), versus nearly a third hosting over 80 stores per square mile. Though only 16.4% lived in a postcode surrounded by >80 stores/mile^2, 35.1% came across these high densities at specific points during their commute.

v. Potential confounders for SLIC and London primary schoolchildren

The dynamics at work in the triad connecting built environmental characteristics, children's physical activity, and body composition are likely to be confounded by the individual and socioeconomic characteristics of SLIC children, their families and neighbourhoods. A descriptive statistical overview of the distribution of the set of potential confounders included in the analyses is provided in *table 6*. These include sex, ethnicity, and age on the individual level, FAS score, free school lunch receipt and car ownership on the family socioeconomic level and, finally, neighbourhood deprivation. For two potential confounders, London-wide data are available, allowing them to be mapped. On the one hand, *map 13* depicts the spatial distribution of self-reported white and BAME SLIC children against a background showing the share of the minority ethnic population in London LSOAs. On the other, the socioeconomic aspect is captured in *map 14*. This map presents the socioeconomic status of SLIC families through the coloured dots at the centroid of their home Output Areas, as well as the quintile scores for the neighbourhood Index of Multiple Deprivation on the LSOA level.

Potential confounders for SLIC children		
Variable	**Number of SLIC children**	**Percentage (%)**
Sex		
Female	1,015	**53.7**
Male	874	**46.3**
Ethnicity		
Black	490	**25.9**
South Asian	515	**27.3**
White/other	884	**46.8**
Age at test (years old)		
5-6	464	**24.6**
7-8	720	**38.1**
9-11	705	**37.3**
Family Affluence Scale		
Low	165	**8.7**
Intermediate	1,208	**63.9**
High	396	**21.0**
Unknown	120	**6.4**
Free School Lunches		
Yes	462	**24.5**
No	1,268	**67.1**
Unknown	159	**8.4**
Cars in the household		
None	438	**23.2**
One	909	**48.1**
Two	434	**23.0**
Unknown	108	**5.7**
IMD Quintile		
Least deprived: 1	177	**9.4**
2	372	**19.7**
3	356	**18.8**
4	375	**19.9**
Most deprived: 5	609	**32.2**

Table 6: Potential confounders for SLIC children

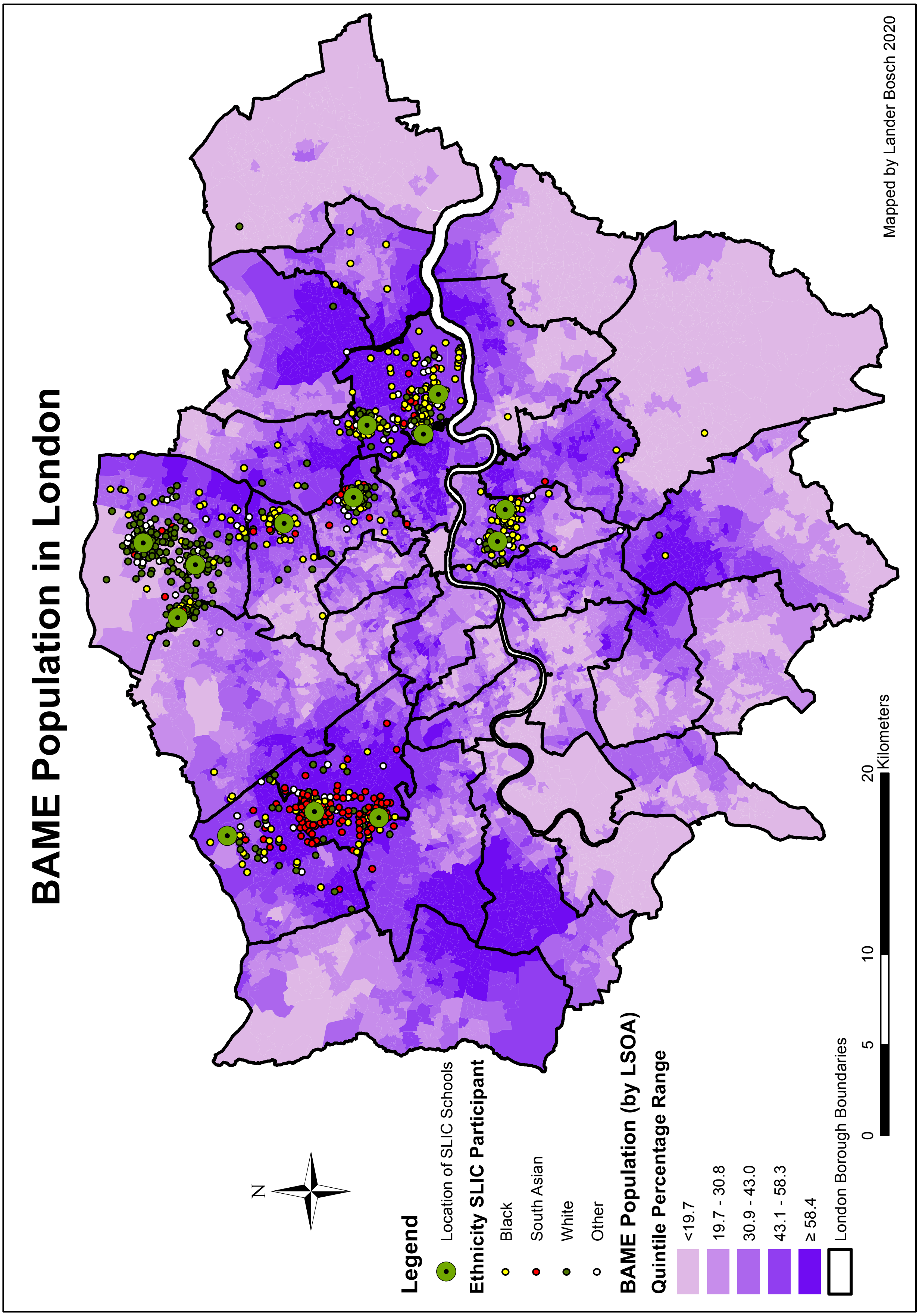
53.7% of the sample were female. About a quarter were aged five to six (24.6%), 38.1% were seven to eight years old, and the remaining 37.3% were aged nine to eleven. Just over a quarter of SLIC children were black, and a similar share was South Asian. The BAME population is particularly well-represented in west and northwest London, where the SLIC participants were predominantly South Asian, and in the south, east and northeast, where SLIC children from minority backgrounds were predominantly black. The included pupils residing in Enfield and Hackney were mostly Caucasian.

About two-thirds of SLIC families had intermediate affluence levels, and a similar share did not receive free school lunches. SLIC children in the northern Boroughs of Harrow and Enfield were more likely to belong to more affluent families. A quarter of families did not own a car. On the neighbourhood level, deprivation shows a similar spatial pattern to crime rates, with large areas of central, north and east London, as well as clusters in the west, being highly deprived along two quasi-perpendicular axes running across the city. 52.1% of SLIC children resided in LSOAs belonging to the lowest two deprivation quintiles.

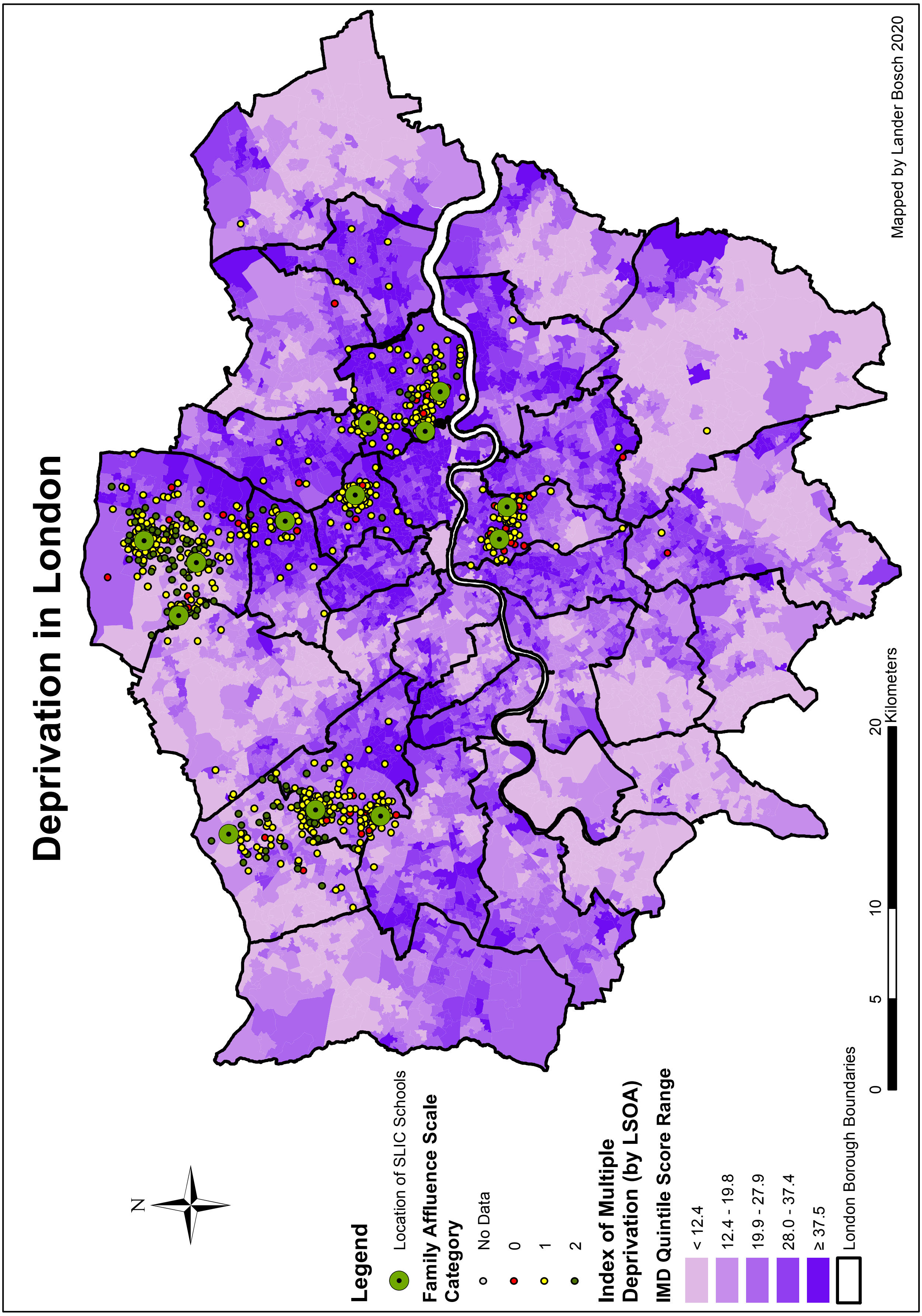
vi. Data clustering

The observation of clear spatial patterns that can be visually extracted from the maps is formally confirmed through the calculation of clustering statistics, as Global Moran's Index scores are computed for each of the included London-wide variables.

Results of these analyses, shown in *table 7*, demonstrate that the mapped variables are significantly autocorrelated and, hence, that the assumption of independence of observations does not hold. The fact that the home and road environments of SLIC children attending the same school and residing in nearby physical and socioeconomic neighbourhoods were likely to be more similar to each other compared to those living further away therefore needs to be accounted for in the statistical analyses.



Map 13: BAME population in London (© see methodology)



Map 14: Deprivation in London (© see methodology)

Spatial autocorrelation results		
Variable	**Moran's I**	**p-value**
BMI Childhood Overweight and Obesity by MSOA	0.35	**<.001*** **
Commuting SLIC Children	0.52	**<.001*** **
Sports frequency SLIC Children	0.14	**.050***
Traffic Risk by LSOA	0.09	**<.001*** **
Personal Risk by LSOA	0.15	**<.001*** **
Air Pollution by LSOA	0.81	**<.001*** **
Walkability by Output Area	0.27	**<.001*** **
Convenience store density	1.30	**<.001*** **
Index of Multiple Deprivation by LSOA	0.55	**<.001*** **
BAME population share	0.66	**<.001*** **

Table 7: Results of the spatial autocorrelation analyses

d. Key takeaways from the cartography and descriptive statistics

The visualisation of core variables in this first of three steps of the spatial epidemiological data analysis protocol, supported by descriptive statistics, provided a powerful insight into the composition of the SLIC dataset and the constituents of the triad tying together children's built environments, physical activity, and body composition. Moreover, the spatial patterning of potential individual, family and neighbourhood confounders could also be explored. The cartography thereby demonstrated that the geographical spread of SLIC schools and participants covers a wide spatial range of built environments and a diverse group of schoolchildren across London, confirming the external validity of the included sample of primary schoolchildren.

The maps and their visual analyses demonstrated that a quantitative cartographic approach is not simply locked into a purely positivist epistemology. Indeed, the created maps were used as *"exploratory devices for thinking through our understanding of complex, dynamic, relational, geographic spaces"* (O'Sullivan et al. 2018, p.136) prior to embarking on the study of their interrelations and relative contributions to stimulating obesogenic behaviours through more complex statistical analyses. The visual representation of spatial data possesses an immediacy enabling the transfer of a sense of knowledge and action seldom matched by numbers or plain text. Moreover, their accessibility to a non-academic audience makes these cartographic representations highly suitable in the substantiation of tailor-made actions and policies.

Despite the insights provided by these maps, the limitations of large-scale mapping also highlight the need to unravel the unique, small-scale interplays of drivers of, and barriers to, children's activity and weight gain. Spatial analyses on the micro-level, as well as the investigation of the potential role played by subjective experiences and perception in the qualitative stage of this study are key to gaining a fuller understanding of this triad. Unveiling the specific dynamics at work in these spatialities will allow to develop tailor-made approaches to foster child activity and tackle the childhood obesity epidemic.

III. Step 2 – Visual interrelations and exploratory statistics

a. Introduction to visual interrelations and exploratory statistics

The cartographic representation of the built environments surrounding SLIC children's homes and schools allowed to gain a clear insight into the spatial distribution of potential obesogenic and leptogenic neighbourhood characteristics across London. The emerging visual patterns thereby pave the way to answering the geospatial part of the central quantitative research question in-depth. To formulate such answer, the existence of interrelations between the objectively measurable environment and behavioural outcomes for participants needs to be visually explored. The resulting spatial evidence on binary relations at work in the triad should also be quantitatively bolstered. This quantification of visual links is achieved through the calculation of exploratory, binary statistics. The outcomes of these binary spatial-statistical analyses are jointly presented in this second step of the Health Geographical data analysis protocol (Gatrell & Elliot 2014).

In this section, first, the pairwise cartographic and statistical associations between each of the six included quantitatively assessed built environmental variables and children's extracurricular physical activity and body composition components are explored. Next, the binary visual and statistical links between SLIC children's mode of commuting and outdoor, extracurricular engagement in sports and exercise and their BMI, FMI and FFMI are established. Finally, for each of these activity and body composition variables, the potential role of confounders is examined by comparing their spatial patterns and computing binary statistical associations between them. Together, these exploratory analyses serve to provide an initial insight into the central quantitative research question prior to the formal data modelling. There, the relative contribution of co-occurring built environmental variables and confounders in these dynamics can be established through multilevel statistical analyses.

As discussed in the methods chapter (chapter 4), all statistical analyses are performed in Stata 15. Spearman rank-order correlation coefficients are computed to study the associations between ordinal categorical and continuous variables, whereas chi-square tests are carried out to examine the relations between nominal-categorical variables.

b. Results & discussion: exploring cartographic interrelations and binary statistics for the SLIC sample

i. The exploratory link between the built environment and children's physical activity and body composition

Table 8 shows the Spearman correlation coefficients resulting from the binary statistical analyses linking the six built environmental characteristics in SLIC children's home neighbourhoods and along the shortest route to school to their categorized mode of commuting, participation in sports and exercise, and body composition. These complement and quantitatively substantiate the visual links between the maps designed in the first step.

<u>The binary link between the built environment and children's physical activity components</u>

Numerous visual interrelations emerge from the pairwise comparison of maps, underpinned by significant binary statistical associations. In particular, the relation between neighbourhood characteristics and SLIC children's mode of commuting to school stands out, with the correlation coefficients of nearly each pair of variables reaching the significance threshold. The cartography shows that pupils' choice of active versus passive commuting appeared to be predominantly distance-based, as the share of participants walking or cycling to school visibly decreased with increasing commuting distance. The importance of a short distance to school to stimulate child activity through active modes of transportation has been extensively described in literature (Rothman et al. 2018). Similar, though slightly weaker associations in the same direction are observed for SLIC children's dominant mode of commuting and neighbourhood facilities that could serve as potential spaces for extracurricular physical activity. Longer distances to the nearest sports and recreation facility or area of greenspace are related to lower levels of active commuting to school among the pupils in the sample. This influential role of the provision of a wide variety of neighbourhood amenities matches the evidence describing positive associations between the vicinity of such facilities and children's active commuting to school and independent mobility in earlier studies (Remmers et al. 2019; Villanueva et al. 2013). The nearby presence of these facilities in a neighbourhood could directly incite children to commute actively to school, or could have an effect through the increased perceived walkability of neighbourhoods where these amenities are present (Lee et al. 2013).

Beyond proximity, objectively assessed levels of risk can influence children's outdoor physical activity engagement. However, the lack of a clear, inverse visual relation between patterns of SLIC children's active commuting and traffic and crime risk demonstrates that children's active transport took place in at times highly dangerous road and personal safety circumstances, corroborating prior research (Zhu & Lee 2008). The cartography thereby demonstrates that the decision to walk, cycle or be active outside for transport thus did not appear to be taken solely based on the quantitatively assessed safety of the streets around SLIC children's homes and schools. Even stronger, whilst negative safety perceptions have been strongly related to reduced levels of active commuting among children (Aarts et al. 2013; Noonan et al. 2017), the binary statistical associations show that higher levels of objectively recorded crime and traffic accidents in SLIC children's home LSOA were associated with higher levels of active commuting. While a similar relation is also found for the average crime rate on the way to school, children with higher maxima of traffic risk *en route* to school were significantly less likely to rely on walking or cycling for their daily commute.

Fourthly, the air pollution map clearly revealed the spatial patterning of areas in London that were confronted with dense motorized transport and high levels of toxic vehicle exhaust. The absence of a visual association between SLIC children's commuting modes and these patterns of pollution suggests that objective levels of air quality and traffic density did not constitute a key factor in determining the choice of the use of active or passive modes of transport. By consequence, children who actively commuted to school in London were thus unequally exposed to potentially harmful pollutants depending on the specific location of their home and school, as well as the route they followed on a daily basis. Indeed, the binary statistics reveal that poorer air quality, and therefore higher traffic density, is associated with more walking and cycling to school among SLIC children, contradicting the little prior research finding an inverse relation between both variables (An et al. 2018). This raises the issue of equity in travel modes and exposure to pollution (Brook et al. 2017). This question is strengthened by the observation that the denser and more connected street network – a key component of Stockton's Walkability Index (Stockton et al. 2016) – in Inner London results in both an increase in toxic vehicle exhaust and a larger number of street crossings. Children living, attending school, moving and exercising in these car-based infrastructural environments therefore face a double health risk. On the one hand, they are exposed to disproportionally high levels of toxic pollutants potentially affecting their health. On the other, a dense set of road crossings might deter them from active commuting (Helbich 2017).

Whilst the cartography shows no clear visual relation between walkability and the commuting mode choices of SLIC children, a positive statistical association between active commuting with the Walkability Index score of the home neighbourhood and route environment is found. This is in accordance with prior studies stating that objective street connectivity, residential density and land use mix play an important role in primary schoolchildren's choice of active means of transportation (Villanueva et al. 2014; Zhu & Lee 2008).

Finally, while the density of convenience stores across London does not have a strong visual association with SLIC children's commuting, the statistics point to a significant binary relation between these variables. The Spearman correlation coefficients show a higher density of convenience stores was significantly related to higher volumes of walking and cycling among SLIC children. Even though very little evidence exists in current literature, these associations could support the hypothesis that the exposure to food on the way to school could impact the mobility behaviour of children (Burgoine et al. 2015).

The statistical analyses for air pollution, walkability and the density of convenience stores in the built environment show similar results, irrespective of whether they are measured in SLIC children's administrative unit of residence or along the way to school. However, whether these associated built environmental variables constitute true, independent facilitators of, or barriers to, active commuting, or are linked to their geographic location and the spatial distribution of confounders, needs to be unravelled in the multilevel modelling analyses.

Variable	Sub-variable	Active Commuting	Sports Frequency	Body Mass Index	Fat Free Mass Index	Fat Mass Index
Proximity (m)	*School*	**-.422*** **	-.004	**.058***	**.066** **	.030
	Nearest sports facility (m)	**-.116*** **	-.044	.030	**.045***	.020
	Nearest park/public garden (m)	**-.129*** **	**-.058***	-.036	-.001	-.007
Traffic risk (Accident rate per 10^4 inhabitants)	*Home LSOA*	**.090*** **	.034	.022	.022	-.001
	Average along route to school	.018	.042	**.087*** **	**.096*** **	.044
	Maximum along route to school	**-.123*** **	.005	**.099*** **	**.129*** **	.043
Personal risk (Crime rate)	*Home LSOA*	**.116*** **	**.077** **	.040	.033	.038
	Average along route to school	**.099*** **	**.067** **	**.081*** **	**.081*** **	**.073** **
	Maximum along route to school	-.041	**.058***	**.091*** **	**.119*** **	**.074** **
Air pollution (Combined Emission Index score)	*Home LSOA*	**.209*** **	**.061***	.044	**.060***	.027
	Average along route to school	**.222*** **	.045	**.075** **	**.084*** **	.039
	Maximum along route to school	**.145*** **	**.046***	**.085*** **	**.094*** **	**.051***
Walkability (Walkability Index Score)	*Home Output Area*	**.107*** **	.027	**.079*** **	**.092*** **	**.051***
	Average along route to school	**.110*** **	.017	**.148*** **	**.181*** **	**.069** **
	Minimum along route to school	**.191*** **	.014	**.126*** **	**.155*** **	**.049***
Foodscape (Convenience store density)	*Home postcode*	**.223*** **	.036	**.069** **	**.081*** **	**.048***
	Average along route to school	**.240*** **	**.063** **	**.048***	**.074** **	.034
	Maximum along route to school	**.168*** **	**.054***	**.065** **	**.094*** **	.038

Table 8: Binary associations between the built environment and SLIC children's physical activity and body composition

Turning attention to the second core extracurricular activity component, fewer built environmental characteristics are visually and statistically correlated with SLIC children's engagement in out-of-school sports and exercise. This suggests that the direct, physical surroundings may have less of an impact on these types of activities, or that perception plays a more crucial role. The cartography does, however, show an inverse trend between the nearby provision of neighbourhood amenities and children's frequency of sports engagement. The larger distances to these potential physical activity facilities could explain the reduced frequency with which participants living in North London are observed to participate in out-of-schools sports and exercise, particularly in Harrow and Brent.

This evidence from the maps is underpinned by the binary statistics. Whilst, surprisingly, no significant association with proximity to sports and recreation facilities is found, participants engaged less frequently in extracurricular physical activity as their shortest distance to public greenspace grew. This is in accordance with prior literature suggesting that the nearby provision of parks and gardens close to the homes of children is important in maintaining high levels of extracurricular energy expenditure (Gascon et al. 2016).

Three additional objectively assessed environmental variables show weak, though significant and positive, binary statistical associations with SLIC children's regular participation in sports and recreation, where cartographic evidence is lacking. First, children residing in or crossing neighbourhoods with higher average or extreme crime rates were more frequently active. A similar finding emerges in relation to higher maxima of air pollution on the way to school and in the home LSOA, as well as for the third characteristic, the density of convenience stores along the commuting route. The observation that more frequently active children tend to do so in objectively less healthy outdoor environments is concerning, and again raises the critical question of the production and reproduction of health inequities in urban settings (Giles-Corti et al. 2016). In contrast, quantitatively assessed traffic risk and walkability do not show significant associations with pupils' recurrent sports and recreation. This could indicate that this activity component takes place at a distance from the direct road environment, or is more strongly determined by perception (Tappe et al. 2013).

The binary link between the built environment and children's body composition components

The binary cartographic and statistical analyses also reveal a series of associations between SLIC children's built environments and their body composition, especially in relation to the road environment between home and school – albeit not always in the expected direction based on previous research.

Looking at the maps, the quasi-perpendicular axes of elevated rates of childhood excess weight measured by BMI, indicated by the dashed blue lines on *map 2*, rather neatly coincide with the spatial variation in personal risk. Indeed, areas where a large share of Year 6 schoolchildren fell in the overweight or obese BMI category tend to align with administrative units with higher levels of recorded crime. Surprisingly, these parts of London are generally also considered to be well-suited for active transport, as their Walkability Index scores often place them in the highest quintiles for walkability. Though less salient, environments with higher shares of excess weight also tend to contain higher convenience store densities, as well as poorer air quality, exposing the children residing there to unhealthy living conditions. The binary statistics support these observations. Participants' BMI is more likely to fall in the overweight and obese categories if they lived further away from school or traversed routes with higher levels of traffic and personal risk, air pollution, walkability and convenience store densities. Whilst the higher BMI scores of children residing in unsafe environments with a high exposure to unhealthy foodstuffs and long distances to neighbourhood facilities follow the hypothesis that objectively assessed obesogenic environments incite weight gain (Morgan Hughey et al. 2019; Saelens et al. 2018), the findings for walkability oppose this trend.

This contradictory picture gets even more complex when total body mass is broken down into its constituent fat and fat-free components for SLIC children. On the one hand, all positive, binary spatial and statistical associations observed between the built environment and SLIC children's BMI are also substantiated by a significant increase in their FFMI. Participants' higher total body weight in obesogenic neighbourhoods thus was, at least in part, due to their stronger development of healthy muscle mass. On the other hand, fewer correlation coefficients meet the significance threshold for relations between the built environment and

FMI. Moreover, if significant, these associations are much smaller in effect size compared to FFMI.

From the maps, higher fat masses seem to consistently appear in parts of London where elevated levels of crime, highly walkable environments, a dense provision of highly calorific food and poor air quality cluster together. However, the statistics show that pupils' categorised fat masses are significantly and positively associated with only walkability and higher levels of personal risk along the route to school. However, even for these two built environmental characteristics, the relation between higher Walkability Index scores and crime rates and an increase in the fat-free component of SLIC children's body mass is distinctly stronger. Similarly, the increased BMI of SLIC children commuting along routes with high traffic risk, air pollution levels and densities of convenience stores appears to be predominantly due to the higher fat-free mass of participants in these areas. The binary statistical associations for these three quantitative neighbourhood variables with FMI return either no significant correlation coefficients with adiposity whatsoever, or a much weaker association for only one of the used metrics. Regarding proximity, participants living further from school or sports and recreation facilities tend to belong to higher FFMI categories. Their adiposity, however, does not vary significantly with the distance to these facilities. Even though solely looking at BMI may thus suggest otherwise, this finding points towards a potential health-inciting effect of longer distances to school and recreational areas. Prior research argues that this effect is likely to be only observed for active commuters who live within the boundaries of what can be considered a walkable distance to facilities (DeWeese & Ohri-Vachaspati 2015).

As hypothesised, BMI thus emerges as a flawed metric, with the spatial and statistical findings pointing to a clear need to disentangle FMI and FFMI in order to gain a deeper understanding of the impact of the built environment on children's body composition (Wells et al. 2002). The stronger muscle development of SLIC children in objectively obesogenic environments, driving their potential classification as overweight or obese in terms of BMI, could potentially be mediated by their levels of extracurricular physical activity (Nesbit et al. 2014; Tu et al. 2016). Therefore, the importance of the role played by physical activity in the built environment-body composition relation should be explored in the multilevel models. In addition, the ambiguity of the binary associations points to the need to unpick the independent contributions of the included environmental characteristics to elevated BMI, FMI and FFMI scores, as well as the exploration of the role of potential confounders.

ii. The exploratory link between children's physical activity and body composition

The Spearman rank-order correlation coefficients describing the interrelations between SLIC children's levels of extracurricular physical activity and their body composition components are displayed in *table 9*. These provide the statistical background to comparison of the maps developed in the first step of the research protocol.

	Active Commuting	Sports Frequency	BMI	FFMI	FMI
Active Commuting		.038	**-.067****	-.035	**-.069***
Sports Frequency	.038		.028	.013	.024
BMI	**-.067****	.028		**.566*****	**.646*****
FFMI	-.035	.013	**.566*****		**.347*****
FMI	**-.069***	.024	**.646*****	**.347*****	

Table 9: Binary associations between SLIC children's physical activity and body composition

From the cartography, no unequivocal link can be established between SLIC children's activity levels and hotspots of childhood overweight and obesity. For certain groups of pupils, for instance those attending school in western Southwark, the expected pattern of an inverse association between activity and weight is observed, as a large share of actively commuting pupils coincides with a predominantly healthy fat mass among most participants. However, around other schools, for instance in Harrow, Enfield and northern Brent, the opposite trend can be detected. There, low levels of overweight and obesity as measured by both the BMI and FMI are observed, despite the large volumes of passive commuters. Analogously, higher frequencies of participation in sports and exercise of certain groups of SLIC children do not clearly correspond to lower adiposity or higher muscle mass levels. Neighbouring Boroughs Hackney and Newham serve as an example here. While both Boroughs host a significant share of SLIC children active on a daily basis, both FMI and FFMI scores are distinctly higher in Newham.

This lack of clear cartographic evidence contrasts with the results of the exploratory binary statistical associations. A weak though significant, negative correlation is found between active commuting to school and the fat mass of SLIC children, also reflected in their lower BMI. This outcome is important, as it opens up an interesting potential pathway for the reduction of childhood overweight and obesity by fostering walking or cycling to school, a finding to be further explored in the multivariate analyses. The potential key role of active commuting in lowering children's fat mass was hinted at in earlier research (Sarmiento et al. 2015). Perhaps surprisingly, the frequency with which children participate in sports was not significantly associated with body composition categories. This opposes earlier research involving children from different ethnicities linking the engagement of children in physical activity of moderate and vigorous intensity to lower obesity levels (Katzmarzyk et al. 2015).

As expected, BMI, FMI and FFMI are also interrelated. However, the absence of a near-linear relationship between total body mass and its constituent components implies there is a degree of variation in children's fat and fat-free mass equilibrium. A child's higher adiposity is thus likely to be reflected in a higher BMI score, but the same observation can be made for a child who had a strongly developed healthy muscle mass. This points to the possible misclassification of healthy children as overweight or obese based on their elevated fat-free mass if the distinction between both components of body mass is not made, as is done in a large proportion of the studies reviewed for this dissertation. FMI and FFMI also positively co-vary, corroborating the muscle-stimulating effect of a fat mass overload on the musculoskeletal system (Tomlinson et al. 2016).

iii. The exploratory link between confounders and children's physical activity and body composition

SLIC children's ethnicity, family socioeconomic status measured by the FAS, and neighbourhood deprivation across London could be mapped. This allows spatial patterns of congruence between these potential confounders and SLIC children's physical activity and body composition to be discerned, substantiated by binary statistics. To quantify their visual interrelation, *table 10* shows the pairwise associations between SLIC children's core activity and body composition components and the individual confounders age, sex and ethnicity. *Table 11* then displays the outcomes of the binary statistical analyses between the former set of dependent variables and family socioeconomic status, measured by the proportion of participants receiving free school lunches, their FAS ranking, and the number of cars in the household. *Table 12,* finally, links pupils' activity and weight status to neighbourhood deprivation.

Significant associations emerge for all confounders in relation to one or more physical activity and body composition outcomes. Studying their relation with physical activity first, a look at the individual confounders shows that, as SLIC children grew older, they were more likely to travel to school actively and participate in sports more frequently. The increased levels of active commuting for older SLIC participants match the findings of prior research describing a similar trend for European primary schoolchildren (Helbich 2017; Aarts et al. 2013; Fyhri & Hjorthol 2009). In contrast, the intensified sports participation with age contradicts the inverse association found in prior UK research using accelerometer data for children in the same age range as the SLIC participants (Jago et al. 2020). It should, however, be cautioned once again that SLIC activity data are self-reported and do not contain objectively collected MVPA measurements.

Frequency of sports engagement also differs significantly by sex, with a higher proportion of SLIC boys (46.7%) participating in daily exercise in comparison to girls (41.9%). While such disparities do not emerge for the selected mode of commuting, the higher male physical activity levels observed are in line with previous evidence (Sterdt et al. 2014).

For the final individual confounder, ethnicity, no significant binary associations – neither cartographically nor statistically – are found with regard to SLIC children's modes of commuting. This contrasts with earlier research in the UK, including London, describing higher rates of passive commuting for black and South Asian children in comparison to whites, corrected for confounders (Owen et al. 2012). Whether this association remains insignificant for SLIC participants when built environmental and other confounding factors are accounted for, will be tested in the multilevel statistical analyses. BAME SLIC children did, however, report structurally higher frequencies of engagement in sports and exercise compared to their peers in the white/other group. 71.8% of black children and 72.2% of South Asian children in the SLIC sample participated in sports more than once a week. For those of white/other ethnicities, this was 66.7%.

Beyond the individual characteristics of SLIC children, the results for their family and neighbourhood socioeconomic status variables show a consistent pattern of geospatial and statistical associations. Participants from less affluent families and living in more deprived neighbourhoods were more likely to actively commute to school and participated in sports more frequently. The summary statistics reveal that the share of children who passively commuted is more than twice as high for children in the wealthiest FAS group and with two cars compared to those from the least affluent families without a car. Analogous findings are obtained in relation to out-of-school sports and exercise. About half of the children in the lowest FAS category or without access to a privately owned car engaged in daily extracurricular physical activity. For children from highly affluent family backgrounds or those with two cars in the household, daily sports participation only reached 37.6%, despite cars as means of transport being a crucial factor in enabling primary schoolchildren to participate in sports (Nielsen et al. 2012). Overall, these findings are in agreement with the literature on the impact of socioeconomic status on children's physical activity (Pouliou et al. 2014), with car ownership often described as the crucial factor entailing an increase in passive commuting (Rothman et al. 2018).

Similar to physical activity, linking confounders to body composition reveals consistent patterns. Whereas no sex differences are found, older SLIC children had significantly higher BMIs. The fact that age and sex have no significant association with FMI or FFMI is explained by the fact that these indices are sample-adjusted, specifically for age and sex. The trend of increasing BMI with age for SLIC participants supports nation-wide data (Baker 2018). However, the binary statistics cannot confirm the higher BMI levels among boys observed in England (Baker 2018).

Exploratory statistics: binary associations between potential individual confounders and SLIC children's physical activity and body composition						
Variable	**Sex (%)**		**Ethnicity (%)**			**Age**
	Male	Female	Black	South Asian	White/Other	
Dominant mode of commuting						*Active commuting*: **ρ_s= .064****
Active	46.8	46.7	41.6	48.3	48.6	
Disagreement	20.7	21.5	25.5	20.4	19.1	
Mixed	0.5	0.5	0.6	0.4	0.5	
Passive	32.0	31.3	32.3	30.9	31.8	
	χ^2 = 0.2		χ^2 = 10.4			
Sports Frequency						*Higher sports frequency*: **ρ_s= .127*****
Never	1.0	1.7	1.0	0.8	1.9	
Less than weekly	3.0	4.6	4.3	4.1	3.5	
Weekly	25.7	24.7	22.9	22.9	27.8	
Most days	23.6	27.1	25.7	22.5	27.0	
Daily	46.7	41.9	46.1	49.7	39.7	
	χ^2 = 9.7*		**χ^2 = 19.5***			
Age- and sex-adjusted BMI z-score						*Higher BMI category:* **ρ_s= .084*****
< 5th percentile, 'underweight'	4.7	3.4	1.8	8.9	2.3	
5th–85th percentile, 'normal weight'	66.4	63.7	56.1	68.6	67.8	
85th–95th percentile, 'overweight'	10.9	13.7	14.5	8.9	13.2	
> 95th percentile, 'obese'	18.1	19.2	27.6	13.6	16.7	
	χ^2 = 6.0		**χ^2 = 88.8*****			
ln(FMI) z-score						*Higher FMI category:* ρ_s= .023
< 5th percentile	2.6	3.3	4.7	1.6	2.8	
5th–85th percentile	82.3	81.5	73.3	84.4	85.1	
85th–95th percentile	8.9	9.3	12.9	7.2	8.1	
> 95th percentile	6.2	6.0	9.1	6.8	4.0	
	χ^2 = 0.7		**χ^2 = 39.7*****			
FFMI z-score						*Higher FFMI category:* ρ_s= .014
< 5th percentile	3.3	3.1	1.4	8.9	0.9	
5th–85th percentile	82.9	82.7	74.5	87.0	84.9	
85th–95th percentile	7.7	9.9	12.7	2.9	10.2	
> 95th percentile	6.1	4.3	11.4	1.2	4.0	
	χ^2 = 5.3		**χ^2 = 163.6*****			

Table 10: Binary associations between potential individual confounders and SLIC children's extracurricular physical activity and body composition

Exploratory statistics: binary associations between potential family socioeconomic confounders and SLIC children's physical activity and body composition								
Variable	**Free School Lunch (%)**		**FAS (%)**			**Car Ownership (%)**		
	Yes	No	Low	Inter-mediate	High	0	1	2
Dominant mode of commuting								
Active	50.2	47.6	63.6	49.4	36.1	60.1	47.4	34.1
Disagreement	21.7	18.1	14.6	21.0	18.7	18.7	21.0	20.3
Mixed	1.3	0.3	1.2	0.3	0.8	0.7	0.5	0.5
Passive	26.8	34.0	20.6	29.3	44.4	20.5	31.1	45.1
	χ^2 = 69.7***		**χ^2 = 82.6*****			**χ^2 = 88.6*****		
Sports Frequency								
Never	2.0	1.1	3.6	0.8	2.0	1.6	1.0	1.4
Less than weekly	5.4	3.1	2.4	4.7	1.0	5.5	3.0	3.2
Weekly	21.4	26.7	19.4	22.8	33.6	19.4	24.9	30.2
Most days	23.4	26.3	24.2	25.6	25.8	22.6	25.7	27.6
Daily	47.8	42.8	50.3	46.1	37.6	50.9	45.4	37.6
	χ^2 = 13.9		**χ^2 = 50.5*****			**χ^2 = 41.4*****		
Age- and sex-adjusted BMI z-score								
< 5th percentile, 'underweight'	2.6	4.6	4.2	4.6	3.3	3.4	4.9	3.7
5th–85th percentile, 'normal weight'	56.5	68.1	63.0	63.7	69.4	63.2	63.9	69.8
85th–95th percentile, 'overweight'	13.4	12.0	14.0	13.0	12.6	13.0	12.4	12.4
> 95th percentile, 'obese'	27.5	15.2	18.8	18.7	15.7	20.3	18.8	14.1
	χ^2 = 39.9***		**χ^2 = 19.9***			**χ^2 = 22.1*****		
ln(FMI) z-score								
< 5th percentile	2.8	2.7	4.2	3.0	1.8	3.0	2.7	2.8
5th–85th percentile	74.5	84.7	80.0	81.6	84.1	80.4	81.5	85.5
85th–95th percentile	12.1	8.0	7.9	9.3	8.8	9.1	9.5	7.8
> 95th percentile	10.6	4.6	7.9	6.1	5.3	7.5	6.3	3.9
	χ^2 = 35.6***		χ^2 = 6.7			χ^2 = 10.5		
FFMI z-score								
< 5th percentile	2.4	3.8	3.6	3.6	2.8	2.0	3.8	3.9
5th–85th percentile	76.8	85.4	83.0	82.5	84.1	82.9	81.2	87.1
85th–95th percentile	11.3	7.6	7.9	8.9	9.1	8.0	9.9	6.9
> 95th percentile	9.5	3.2	5.5	5.0	4.0	7.1	5.1	2.1
	χ^2 = 42.6***		χ^2 = 11.8			**χ^2 = 29.0*****		

Table 11: Binary associations between potential family socioeconomic confounders and SLIC children's extracurricular physical activity and body composition

Exploratory statistics: binary associations between neighbourhood deprivation and SLIC children's physical activity and body composition			
Variable	**Index of Multiple Deprivation (%)**		
	Low	Intermediate	High
Dominant mode of commuting			
Active	38.9	42.4	52.6
Disagreement	21.9	22.5	20.2
Mixed	0.2	0.3	0.7
Passive	39.0	34.8	26.5
	χ^2 = 38.0***		
Sports Frequency			
Never	1.1	1.4	1.5
Less than weekly	3.5	3.9	4.1
Weekly	33.1	21.6	22.1
Most days	25.1	23.6	26.3
Daily	37.2	49.5	46.0
	χ^2 = 30.2***		
Age- and sex-adjusted BMI z-score			
< 5^{th} percentile, 'underweight'	4.0	5.9	3.2
5^{th}–85^{th} percentile, 'normal weight'	70.7	64.9	61.8
85^{th}–95^{th} percentile, 'overweight'	11.8	13.2	12.4
> 95^{th} percentile, 'obese'	13.5	16.0	22.6
	χ^2 = 26.5***		
ln(FMI) z-score			
< 5^{th} percentile	2.0	2.2	3.8
5^{th}–85^{th} percentile	87.4	84.3	77.8
85^{th}–95^{th} percentile	7.3	7.3	10.8
> 95^{th} percentile	3.3	6.2	7.6
	χ^2 = 25.9***		
FFMI z-score			
< 5^{th} percentile	4.2	4.2	2.3
5^{th}–85^{th} percentile	84.7	85.4	80.8
85^{th}–95^{th} percentile	8.2	5.6	10.4
> 95^{th} percentile	2.9	4.8	6.5
	χ^2 = 22.0**		

Table 12: Binary associations between potential neighbourhood deprivation and SLIC children's extracurricular physical activity and body composition

Looking at BMI in relation to ethnicity, South Asian children were more often confronted with underweight in comparison to other ethnic groups. The maps show, however, that this is primarily associated with their weaker muscle development. The adiposity of pupils with South Asian ancestry does not appear to differ strongly from that of children in the black, white or other ethnic groups. On the other hand, BMI-assessed childhood overweight and obesity seems to be particularly high among the group of black participants. However, disentangling body composition shows that these kids have both strongly developed fat and fat-free masses, resulting in their potential misclassification as overweight or obese solely on the basis of their BMI.

The statistics confirm these cartographic observations. The proportion of black SLIC children with a BMI in the overweight or obese categories (42.1%) is significantly higher than that for children of white/other ethnicities (29.9%) and South Asian children (22.5%). This contrast is reduced when FMI was analysed, although interethnic differences remain significant. The proportion of South Asian children with an FMI percentile in the obese category is higher than for the white/other ethnic group (6.8% versus 4.0%). However, the largest differences are observed for FFMI percentile scores. 24.1% of children of black ethnicity had an FFMI percentile score above the 85th percentile. For the white/other group, this was 14.2%, for South Asians only 4.1%. As was noted in the cartographic analyses, the distinction between fat and fat-free mass thereby once again points towards the potential misclassification of black and South Asian children if only BMI results are used. While the literature is inconclusive on the role played by ethnicity (El-Sayed et al. 2011), using BMI, similar outcomes to those for the SLIC sample were obtained in prior UK research. Employing this flawed metric, black children turn out to have higher, and South Asian children lower, overweight and obesity odds (Zilanawala et al. 2015). Consistent data on the fat and fat-free mass of primary schoolchildren that would allow for a comparison with the SLIC sample are lacking.

In relation to family socioeconomic status, significant differences emerge for all three body composition indices. The maps show that spatial disparities in family and neighbourhood socioeconomic status overlap with the occurrence of obesogenic neighbourhoods and children's adiposity, both across London and specifically for SLIC participants. The statistics support this cartographic evidence, with SLIC children receiving free school lunches being more prone to falling in the highest BMI (27.5% versus 15.2%), FMI (10.6% versus 4.6%) and FFMI (9.5% versus 3.2%) categories compared to those who do not. FAS differs significantly for participants' BMI, with higher obesity rates found among children of low and intermediate family affluence. Increased car ownership is significantly associated with lower BMI. A similar significant downward trend is observed only for FFMI, and not FMI, hinting at a potential stronger muscle-reducing effect of family car ownership. Finally, increased neighbourhood deprivation is linked to higher BMI, FMI and FFMI. The link between higher obesity levels and lower family and neighbourhood socioeconomic status is well-established, also in the UK (Shackleton 2014; Howard Wilsher et al. 2016). Nonetheless, the overwhelming majority of this evidence relies solely on BMI data, requiring the in-depth analysis of body composition in relation to family and neighbourhood deprivation.

c. Key takeaways from the exploratory statistical analyses

The exploratory binary cartographic and statistical analyses found strong disparities in obesogenic environments and health outcomes for SLIC children across London, exacerbated by individual, family and neighbourhood socioeconomic inequalities. The numerous significant associations obtained point towards intense relations between variables included in the triad of the built environment, children's extracurricular physical activity and body composition. The analyses thereby provided an initial answer to the central quantitative research question whilst simultaneously indicating potential spearheads of effective childhood overweight and obesity policy in London. These hint at the need for a spatially and socially differentiated set of actions, combining targeted micro-level interventions with society-wide policies.

In order to fight the epidemic of childhood overweight and obesity in London, the positive association between active travel to school and reduced adiposity opens up a particularly interesting pathway that requires further exploration. Active commuting can be done on a daily basis by those children residing within walking or cycling distance from school, and does not require significant financial resources. Proximity emerged as the key correlate of SLIC children's activity, though higher levels of walking, cycling and extracurricular sports and exercise were often observed in more unsafe and polluted, though objectively walkable neighbourhoods. This shows that the provision of safe, healthy and clean environments with walking and cycling infrastructure tailored to children's needs is just as, if not more, important and decisive in policies aiming to facilitate physical activity and reduce overweight and obesity. The elevated air pollution and deprivation levels in those places raise important questions about the equity of children's exposure to toxic environments.

The pairwise spatial-statistical associations also unveiled a clear and direct binary link between environmental characteristics and participants' body composition. These findings underline the need to separate the fat and fat-free components of children's total body mass, as the associations with the muscle development of SLIC pupils emerged as pivotal, at times in the unexpected direction. Children from less advantaged socioeconomic backgrounds were found to be at increased risk of being confronted with excess weight. Clusters of children with excess fat mass resided in unsafe, polluted and deprived – though objectively walkable – neighbourhoods with a large exposure to unhealthy food options. Nonetheless, these children were also more physically active than their well-off peers. Children from BAME ancestries also tended to have less healthy body compositions compared to their peers in the white/other group, despite engaging in extracurricular sports and exercise more frequently.

The nature and drivers of these inequalities remain poorly understood, and the lack of their full comprehension in prior research is perpetuated by the use of indiscriminate activity measures and flawed body weight metrics, such as BMI as an indicator of overweight and obesity. These produced skewed, and at times even wholly invalid results. The disentanglement of core variables of physical activity and body composition is therefore vital, as is the study of the relative contribution of built environmental characteristics in driving or hampering children's activity and adiposity and the inclusion of confounders. The multilevel, multivariate statistical analyses in the next section can contribute to filling these gaps. The exploratory analyses highlighted the urgency to investigate the observed associations qualitatively, grounded in the real lifeworld of children, to examine the role of subjective experiences and perception. This will be achieved through the go-along interviewing described in the next chapter.

IV. Step 3 – Multilevel Modelling Analyses

a. Introduction to mixed-effects ordered logistic regression modelling

The findings from the exploratory cartographic and statistical analyses suggest a close relationship between the built environments of SLIC children and their extracurricular physical activity and body composition, strongly impacted by confounders. These binary associations serve as the basis for the elaboration of the full-scale, formal statistical analyses in the third and final step of the spatial epidemiological research protocol. Accounting for the role of confounders and the nested data structure in the statistical models allows the quantification of the independent effects of explanatory variables. The relative contribution of each of the variables and confounders included in the triad is therefore scrutinized through multivariate data modelling in this section, delivering a comprehensive answer to the statistical component of the quantitative research question.

As discussed in the literature review and methodological chapter (chapters 3 & 4), there is tremendous value in breaking down this overarching question into its composite steps. Hence, the results for the mixed-effect ordered logistic regression models on the level of the individual child and the attended school are presented and discussed step-by-step. Firstly, the relation between the built environment and SLIC children's out-of-school physical activity is scrutinised. The second set of models then examines the link between this physical activity and childhood overweight and obesity for the retained sample of study participants. Thirdly and finally, the direct associations between the built environment and body composition of SLIC children are explored.

Model results are shown as the Odds Ratios (OR) of belonging to higher categories of dependent extracurricular physical activity or body composition variables, with 95% CIs. For each model, the result of the Wald chi-square (Wald χ^2) test, indicating the significance of the set of included explanatory variables, is also displayed.

b. Results & Discussion: a three-step statistical analysis linking SLIC children's built environment, out-of-school physical activity, and body composition

i. Step 1: Multilevel models linking the objective built environment to SLIC children's extracurricular physical activity

The first step examines the home and road environments of SLIC children in relation to their core components of out-of-school physical activity. Together, the models describing this relation can provide an extensive answer to the first quantitative sub-question:

> *"Controlling for potential confounders, which built environmental characteristics stimulate or counteract the extracurricular physical activity of London primary schoolchildren, starting from a predefined set of elements based on the extensive literature review?"*

Linking the built environment to SLIC children's commuting mode choices

Considering children's school travel first, *table 13* displays the link between the average and extreme values for each individual built environmental characteristic along the shortest route to school and SLIC children's likelihood of commuting actively. Each of these eleven individual models is fully corrected for potential individual confounders age, sex and ethnicity, as well as SLIC children's family and neighbourhood socioeconomic status.

Based on the strength and significance of their independent, individual associations with commuting, either the average or extreme value for each environmental variable is then retained for inclusion in the comprehensive model, bringing together the six predefined built environmental variables within the same model. *Table 14* shows the results of this comprehensive model for active school travel, fully adjusted for individual and socioeconomic confounders.

Associations between individual built environmental measures and SLIC children's active commuting		
Variable	**Odds Ratio [Confidence interval]**	**p-value**
Proximity to School	*Wald χ^2 = 235.8*	*<.001*
Shortest route distance to school (m) - reference: <500.0		
500.0-999.9	**0.616 [0.385-0.986]**	**.043***
1,000.0-1,499.9	**0.301 [0.188-0.482]**	**<.001*****
≥ 1,500.0	**0.115 [0.073-0.182]**	**<.001*****
Average Traffic Risk along Route LSOAs	*Wald χ^2 = 73.0*	*<.001*
Average accident rate per 10^4 inhabitants crossed - reference: <20.0		
20.0-39.9	**0.636 [0.501-0.807]**	**<.001*****
≥ 40.0	**0.586 [0.397-0.863]**	**.007****
Maximum Traffic Risk along Route LSOAs	*Wald χ^2 = 97.9*	*<.001*
Highest accident rate per 10^4 inhabitants crossed - reference: <20.0		
20.0-39.9	**0.481 [0.317-0.729]**	**.001****
≥ 40.0	**0.315 [0.216-0.459]**	**<.001*****
Average Personal Risk along Route LSOAs	*Wald χ^2 = 62.8*	*<.001*
Average crime rate crossed - reference: <90.0		
90.0-109.9	0.832 [0.553-1.250]	.375
≥ 110.0	1.247 [0.824-1.887]	.296
Maximum Personal Risk along Route LSOAs	*Wald χ^2 = 85.2*	*<.001*
Highest crime rate crossed - reference: <90.0		
90.0-109.9	**0.592 [0.387-0.906]**	**.016***
≥ 110.0	**0.446 [0.330-0.602]**	**<.001****
Average Air Pollution along Route LSOAs	*Wald χ^2 = 60.7*	*<.001*
Average Combined Emission Index crossed - reference: <90.0		
90.0-109.9	1.218 [0.848-1.750]	.286
≥ 110.0	1.393 [0.816-2.377]	.224
Maximum Air Pollution along Route LSOAs	*Wald χ^2 = 65.4*	*<.001*
Highest Combined Emission Index crossed - reference: <90.0		
90.0-109.9	**0.600 [0.402-0.894]**	**.012***
≥ 110.0	**0.522 [0.315-0.867]**	**.012***
Average Walkability along Route Output Areas	*Wald χ^2 = 67.2*	*<.001*
Average quintile crossed - reference: 1 (least walkable)		
2	1.019 [0.677-1.534]	.928
3	1.037 [0.636-1.691]	.884
4	1.429 [0.803-2.543]	.225
5 – Most walkable	**2.611 [1.209-5.639]**	**.015***
Minimum Walkability along Route Output Areas	*Wald χ^2 = 82.5*	*<.001*
Lowest quintile crossed - reference: 1 (least walkable)		
2	**1.682 [1.239-2.285]**	**.001****
3	**2.082 [1.371-3.162]**	**.001****
4	**3.994 [2.070-7.703]**	**<.001*****
5 – Most walkable	1.296 [0.266-6.318]	.749
Average Foodscape Density along Route Postcodes	*Wald χ^2 = 76.6*	*<.001*
Average convenience stores/mile^2 crossed - reference: ≤20		
21-50	1.307 [0.663-2.578]	.440
51-80	**4.755 [1.973-11.459]**	**.001****
> 80	**2.813 [1.161-6.820]**	**.022***
Maximum Foodscape Density along Route Postcodes	*Wald χ^2 = 60.8*	*<.001*
Highest convenience stores/mile^2 crossed - reference: ≤20		
21-50	0.542 [0.183-1.601]	.268
51-80	0.488 [0.160-1.493]	.209
> 80	0.581 [0.176-1.923]	.374

Table 13: Multilevel associations between individual built environmental measures and SLIC children's active commuting

Comprehensive multilevel associations between built environmental characteristics, potential confounders and SLIC children's active commuting		
Variable	*Wald $\chi^2 = 254.7; p < .001$*	
	Odds Ratio [95% Confidence interval]	**p-value**
Proximity		
Shortest route distance to school (m) - reference: <500.0		
500.0-999.9	**0.615 [0.380-0.995]**	**.047***
1,000.0-1,499.0	**0.295 [0.182-0.479]**	**<.001*** **
≥ 1,500.0	**0.117 [0.071-0.192]**	**<.001*** **
Maximum Traffic Risk along Route LSOAs		
Highest accident rate per 10^4 inhabitants crossed - reference: <20.0		
20.0-39.9	**0.592 [0.370-0.946]**	**.029***
≥ 40.0	0.710 [0.418-1.207]	.206
Maximum Personal Risk along Route LSOAs		
Highest crime rate crossed - reference: <90.0		
90.0-109.9	1.029 [0.603-1.755]	.916
≥ 110.0	0.861 [0.559-1.327]	.498
Maximum Air Pollution along Route LSOAs		
Highest Combined Emission Index crossed - reference: <90.0		
90.0-109.9	1.121 [0.701-1.793]	.634
≥ 110.0	1.121 [0.612-2.053]	.712
Minimum Walkability along Route Output Areas		
Lowest quintile crossed - reference: 1 (least walkable)		
2	1.017 [0.713-1.451]	.926
3	0.999 [0.637-1.567]	.996
4	0.964 [0.474-1.963]	.920
5 – Most walkable	1.004 [0.186-5.422]	.996
Average Foodscape Density along Route Postcodes		
Average convenience stores/mile^2 crossed - reference: ≤20		
21-50	1.156 [0.557-2.398]	.697
51-80	**3.380 [1.313-8.698]**	**.012***
> 80	1.628 [0.608-4.360]	.332
Sex *(reference: female)*		
Male	0.973 [0.793-1.193]	.789
Age at test*; years from 5 to 11*	**1.089 [1.022-1.162]**	**.009****
Ethnicity *(reference: white/other)*		
Black	**0.539 [0.394-0.737]**	**<.001*** **
South Asian	0.817 [0.601-1.111]	.197
FMI Weight Status *(reference: Normal fat mass)*		
Underweight (<5th percentile)	1.114 [0.567-2.187]	.755
Overweight (85th-95th percentile)	0.846 [0.600-1.194]	.342
Obese (≥ 95th percentile)	**0.569 [0.371-0.873]**	**.010***
Family Affluence Scale *(reference: low)*		
Moderate	0.816 [0.539-1.235]	.336
High	**0.578 [0.356-0.936]**	**.026***
Free school lunches *(reference: no)*		
Yes	0.927 [0.685-1.255]	.625
Cars owned *(reference: 0)*		
1	**0.593 [0.443-0.795]**	**<.001*** **
2	**0.464 [0.321-0.671]**	**<.001*** **

IMD *(reference: low)*		
Intermediate	0.912 [0.651-1.275]	.589
High	0.757 [0.511-1.123]	.167
Level 2: Variance on School Level	0.276 [0.094-0.812]	

Table 14: Comprehensive multilevel associations between built environmental characteristics, potential confounders and SLIC children's active commuting

The individual multilevel models in *table 13* demonstrate that, independent of confounders, the objectively assessed characteristics of SLIC children's road environments are closely related to their likelihood of actively traveling to school. The individual models confirm that children living further away from school had significantly lower odds of actively commuting to school compared to those residing within 500 metres. This inverse relationship intensifies as commuting distance increases. Both average and extreme rates of traffic accidents along the route to school are significantly associated with SLIC children's commuting mode choices as well. Participants exposed to higher road risk were significantly less likely to travel actively to school, an effect becoming stronger as danger increased. SLIC children who needed to pass through an LSOA with higher extreme crime rates were also significantly less likely to actively commute to school. Again, the effect size increases as crime rates rise. No significant associations are found for average personal risk. In terms of air quality, only maximum pollution levels are significant. Children confronted with higher maxima of airborne pollutant concentrations were less likely to use active modes of transport. Children with the most walkable commutes on average were significantly more likely to walk or cycle to school compared to participants with the least walkable commuting trajectories. Similar observations can be made for walkability extremes, except for the fifth quintile. Finally, an average convenience store density of over 50 outlets/mile^2 along the shortest route to school is associated with significantly higher active commuting odds in comparison to a route with the lowest average density. No such associations are found for density extremes.

Given their significant associations with commuting choices, the extremes of traffic risk, personal risk, air pollution and walkability are retained in the fully corrected model including all built environmental variables and potential confounders. For the foodscape, the relation with average convenience store density is stronger. Hence, this average measure is selected. Three variables retain their significant associations with commuting mode choices in the comprehensive model (*table 14*). First, SLIC participants residing further away from school have lower odds of walking or cycling to school. This proximity effect becomes stronger as distance increases. Secondly, in comparison to children exposed to the lowest accident rates, those confronted with intermediate traffic risk were less likely to actively commute. Finally, children exposed to an average density of 51-80 convenience stores/mile^2 have over three times the odds of commuting actively compared to their peers surrounded by the lowest food outlet densities.

Analysing the associations of the six built environmental characteristics with the commuting mode choices of SLIC children separately, distance to school is consistently and negatively related to a higher likelihood of active commuting to school, both in the individual and comprehensive models, and irrespective of potential confounders or mediators. The associations are stronger for longer commutes. This is in line with ample prior evidence pointing to the importance of a limited distance to school in the decision to walk or cycle (Aarts et al. 2013; Garnham-Lee et al. 2016; Timperio et al. 2015). The odds ratios for active versus passive or mixed commuting for pupils residing over 1,500 metres from school are just over one-tenth of those living closest to school. Even though they form a very small minority of active commuters, separate analyses for SLIC pupils cycling to school lead to similar conclusions (results not shown). Hence, the criterion distance for walking to school for children, set around 1.5 kilometres (D'Haese et al. 2011; Rodríguez-López et al. 2017), should be interpreted as a hard barrier to active commuting for this sample of London schoolchildren.

Longer distances to school are not only related to longer travel times, but also to increased practical constraints and safety concerns (Murtagh et al. 2016). The cartography already demonstrated that longer commutes increases the likelihood that children encounter disadvantageous environmental conditions along the way. The strategic location of schools within the walkable catchment area of neighbourhoods with a high population share of schoolchildren might thus increase levels of active commuting (Murtagh et al. 2016; Rodríguez-López et al. 2017). Moreover, this might reduce the need to supply free public transport, which is provided to pupils deemed to live too far from the nearest suitable school or commuting along unsafe walking routes. Currently, boundaries for free school transport in the UK are set at 3.2 kilometres for children aged 8 or under, and 4.8 kilometres for those aged 8-16 (UK Government 2020).

SLIC children were less likely to actively commute if their shortest route crossed unsafe neighbourhoods. In the individual models, both average and extreme accident risk show significant associations with mode of commuting, as do extreme crime rates. The association between unsafe traffic conditions and children's lower odds of active commuting remains significant in the comprehensive model for the group encountering a maximum accident level between 20 and 40 per 10,000 inhabitants. This link between higher exposure to more hazardous road environments and a lower likelihood of walking or cycling to school supports earlier research in a Dutch context (Helbich et al. 2016). It also shows that the 'worst case scenario' along part of the route may act as a particularly strong deterrent to active travel (Larsen et al. 2016). As actively commuting children, and cyclists in particular, are extremely vulnerable road users (Department for Transport 2018; Dirks et al. 2016), the need for interventions to reduce the risk of traffic injuries is pressing. The traffic safety map showed that hotspots of risk occur across the city, making this a London-wide concern. Prior research has highlighted that (primarily parental) safety perceptions can be decisive in determining children's activity (An et al. 2017). However, the findings for SLIC children indicate that objective safety can also be linked to commuting decisions, or, that parental perceptions closely match objective risks. Providing an objectively safe commuting environment is thus pivotal, though perception can be slow to respond to objective changes. Hence, a safer environment might not automatically result in higher levels of active transport, if it is not followed by an immediate or longer-term increase in perceived safety (Oluyomi et al. 2014).

In the individual model, highs of pollutant concentrations are also found to significantly reduce the odds for participants to use active transport, with their ensuing passive transport generating even more toxic vehicle exhaust. SLIC children thus appeared to be deterred by unhealthy levels of air pollution and, as a proxy, by dense traffic *en route* to school, which the maps showed to cluster in Central London and along major traffic arteries. This finding was not retained in the comprehensive model, perhaps due to the predominance of more immediate road risks over air quality concerns and the strong correlation between accident rates and traffic density. Nonetheless, addressing high levels of air pollution is vital, given the disproportional exposure of active commuters to airborne toxins (Dirks et al. 2016).

The results also add to the hitherto equivocal evidence for walkability (Gascon et al. 2016). Contrary to the binary statistics and in analogy to earlier findings for adults, the results for the individual model in this study underline that the combination of high residential density, street connectivity and land use mix, highest in Central London, could stimulate children's physical activity. A similar, positive association was found in three out of five cases elsewhere in Europe (D'Haese et al. 2015). However, the lack of significant associations in the comprehensive model for participants to the SLIC study shows that other built environmental characteristics are more influential, and an alternative index is thus required for children.

For the final built environmental variable, the foodscape, the individual multilevel model reveals that SLIC children surrounded by 50 convenience stores/mile^2 or more on average had higher odds of active commuting than those living in areas with the lowest outlet densities. This significant association is retained in the comprehensive model for participants encountering an average of 51-80 convenience stores/mile^2 during the school commute. These children, mainly residing closer to the centre of London, were thus disproportionally exposed to unhealthy nutritional options. This association might be the consequence of an activity-inciting effect of convenience stores, acting as potential intermediate destinations during the school commute and providing a certain sense of safety for children, or be caused by the strategic location of such stores in areas with high volumes of active commuters (Susilo et al. 2013). If the first interpretation is correct, then the potential reduction in actively commuting children should be compensated by offering alternative incentives to walk or cycle, for instance reduced air pollution and safer road environments. The latter interpretation supports initiatives aimed at reducing the number of convenience stores around schools, and stimulating the healthy food options they offer (GLA 2018b).

Looking at potential individual confounders, no significant sex differences emerge. Prior research on this association has often produced conflicting results (Faulkner et al. 2009). The findings for SLIC children agree with previous Dutch and US studies (Helbich 2017), but contrast with earlier UK research suggesting boys are more likely to actively commute (Carver et al. 2014). The latter study, however, focused specifically on independent mobility, where sex-differences might be more pronounced. Older SLIC children were significantly more likely to actively commute, in keeping with the growing evidence on this relationship across Europe, including the UK (Aarts et al. 2013; Fyhri & Hjortol 2009; Helbich 2017; Potoglou & Arslangulova 2017). Within the SLIC sample, black children had about half the odds of walking or cycling to school in comparison to those in the white/other group. No such difference is found for South Asian children. Earlier UK research points out that black African-Caribbean primary schoolchildren are more likely to travel by public transport, and tend to live further away from school than children from other ethnicities (Easton & Ferrari 2015; Owen et al. 2012). Black SLIC pupils, predominantly residing in south, east and northeast London, were less likely to walk or cycle, independent of proximity or other built environmental and socioeconomic characteristics. Their areas of residence should therefore be a prime focus of physical activity interventions. Ethnicity can play both a confounding and mediating role in this relation, as the social environment generated by ethnic residential segregation might shape physical activity behavioural choices (Suglia et al. 2016). To account for potential reverse causality, participants' FMI was also included in these analyses. Children in the obese category were less likely to actively commute than those with healthy fat mass levels, although the direction of this relation cannot be conclusively determined. Whilst being the most appropriate measure of adiposity, FMI is rarely used in studies relating body composition to activity. The large majority of earlier studies, using predominantly using BMI and fat mass percentage, obtains conflicting evidence on this relation (Larouche et al. 2014; Wells et al. 2002).

Turning attention to socioeconomic status reveals that children from highly affluent families and from families owning a car had about half the odds of actively commuting to school in comparison to those in the least affluent group or without access to a car, a trend widely supported throughout literature (Oliver et al. 2015; Rothman et al. 2018). This group of affluent SLIC families mainly resided towards the northern fringes of London. Neighbourhood deprivation is not significantly associated with these children's commuting choices. Conflicting associations in relation to the consequences of diverging deprivation levels on children's commuting emerge from prior research. Children residing and attending schools in neighbourhoods of lower socioeconomic status are found to have higher (Molina-García &

Queralt 2017; Pabayo et al. 2012) or lower (Aarts et al. 2013; Panter et al. 2010b) levels of walking and cycling to school and physical activity, depending on the research location and context. Whilst area variation is partly captured by the second level of the multilevel models, the null-findings for SLIC children suggest that family socioeconomic status is more decisive in shaping commuting choices. Moreover, the UK social housing policy is explicitly aimed at creating socially mixed neighbourhoods (Manley & van Ham 2011). This may reduce socioeconomic residential segregation and thereby reduce the impact of small-scale neighbourhood deprivation. Finally, perceptions of deprivation might also be dominant here.

In sum, the results from this first step of formal data modelling show how objectively measurable characteristics of the London built environment can be used to predict the commuting behaviour of the primary schoolchildren participating in the SLIC study. Proximity to school is the key characteristic associated with active commuting to school. However, personal and road safety and the provision of a healthy environment in terms of food options and air pollution along the route to school also require the attention of urban planners and policymakers. Moreover, specific attention should be paid to children from minority backgrounds and affluent families.

Linking the built environment to SLIC children's out-of-school sports and exercise engagement

Switching attention to the second key out-of-school activity component, *table 15* presents the results of the multilevel models linking the value for each individual built environmental characteristic observed in a participant's administrative unit of residence to their likelihood of frequently participating in out-of-school sports and exercise. These seven individual models are fully corrected for potential confounders.

Following this set of results, the findings for the comprehensive, fully-adjusted model including all six built environmental measures simultaneously are shown and discussed in *table 16*. The choice to include either the distance to the nearest sports facility or to the nearest park or public garden as the measure for proximity in this model is once again made depending on the strength and significance of their independent associations with sports and exercise frequency in the individual models.

Multilevel associations between individual built environmental characteristics and SLIC children's frequency of sports participation, corrected for confounders		
Variable	**OR [Confidence interval]**	**p-value**
Proximity to Nearest Sports Facility	*Wald χ^2 = 35.0*	*.006*
Shortest route distance (m) - reference: <500.0		
500.0-999.9	0.809 [0.528-1.240]	.331
1,000.0-1,499.9	0.941 [0.608-1.457]	.786
≥ 1,500.0	0.862 [0.558-1.331]	.502
Proximity to Nearest Park or Public Garden	*Wald χ^2 = 35.4*	*.006*
Shortest route distance (m) - reference: <500.0		
500.0-999.9	0.955 [0.748-1.219]	.711
1,000.0-1,499.9	0.906 [0.680-1.206]	.499
≥ 1,500.0	0.752 [0.499-1.132]	.172
Traffic Risk in the Home LSOA	*Wald χ^2 = 30.9*	*.014*
Accident rate per 10^4 inhabitants - reference: <20.0		
20.0-39.9	1.073 [0.853-1.350]	.547
≥ 40.0	0.929 [0.729-1.185]	.555
Personal Risk in the Home LSOA	*Wald χ^2 = 30.2*	*.017*
Crime rate - reference: <90.0		
90.0-109.9	0.993 [0.714-1.382]	.968
≥ 110.0	1.078 [0.836-1.389]	.563
Air Pollution in the Home LSOA	*Wald χ^2 = 30.9*	*.014*
Combined Emission Index - reference: <90.0		
90.0-109.9	1.151 [0.873-1.517]	.320
≥ 110.0	1.067 [0.722-1.575]	.746
Walkability in the Home Output Area	*Wald χ^2 = 35.0*	*.009*
Walkability Index quintile - reference: 1 (least walkable)		
2	0.890 [0.683-1.161]	.391
3	0.893 [0.654-1.220]	.478
4	0.911 [0.660-1.256]	.569
5 – Most walkable	0.788 [0.552-1.124]	.189
Foodscape Density in the Home Postcode Area	*Wald χ^2 = 33.5*	*.010*
Convenience stores/mile^2 - reference: ≤20		
21-50	1.058 [0.714-1.568]	.777
51-80	1.010 [0.618-1.652]	.968
> 80	0.879 [0.521-1.485]	.631

Table 15: Multilevel associations between individual built environmental characteristics and SLIC children's frequency of sports participation

Comprehensive multilevel associations between built environmental characteristics, potential confounders and SLIC children's frequency of sports participation		
Variable	*Wald* χ^2 *= 37.7; p = .157*	
	OR [95% Confidence interval]	**p-value**
Proximity to Nearest Park or Public Garden		
Shortest route distance (m) - reference: <500.0		
500.0-999.9	0.936 [0.724-1.210]	.614
1,000.0-1,499.9	0.927 [0.687-1.251]	.622
≥ 1,500.0	0.761 [0.492-1.177]	.220
Traffic Risk in the Home LSOA		
Accident rate per 10^4 *inhabitants - reference: <20.0*		
20.0-39.9	1.016 [0.800-1.290]	.897
≥ 40.0	0.837 [0.625-1.120]	.232
Personal Risk in the Home LSOA		
Crime rate - reference: <90.0		
90.0-109.9	1.004 [0.709-1.421]	.982
≥ 110.0	1.162 [0.869-1.553]	.311
Air Pollution in the Home LSOA		
Combined Emission Index - reference: <90.0		
90.0-109.9	1.211 [0.877-1.670]	.244
≥ 110.0	1.230 [0.764-1.980]	.394
Walkability in the Home Output Area		
Walkability Index quintile - reference: 1 (least walkable)		
2	0.850 [0.644-1.120]	.248
3	0.860 [0.621-1.190]	.362
4	0.889 [0.631-1.253]	.502
5 – Most walkable	0.776 [0.528-1.141]	.197
Foodscape Density in the Home Postcode Area		
Convenience stores/mile^2 *- reference: ≤20*		
21-50	0.963 [0.632-1.467]	.860
51-80	0.937 [0.547-1.605]	.812
> 80	0.725 [0.399-1.319]	.292
Sex *(reference: female)*		
Male	1.193 [0.987-1.443]	.068
Age at test; *years from 5 to 11*	**1.142 [1.075-1.212]**	**<.001*** **
Ethnicity *(reference: white/other)*		
Black	1.084 [0.818-1.436]	.574
South Asian	1.065 [0.806-1.407]	.659
FMI Weight Status *(reference: Normal fat mass)*		
Underweight (<5th *percentile)*	0.573 [0.321-1.023]	.060
Overweight (85th*-95*th *percentile)*	0.912 [0.659-1.260]	.576
Obese (≥ 95th *percentile)*	0.885 [0.592-1.324]	.553
Family Affluence Scale *(reference: low)*		
Moderate	0.922 [0.632-1.346]	.674
High	0.839 [0.539-1.307]	.438
Free school lunches *(reference: no)*		
Yes	1.167 [0.889-1.531]	.266
Cars owned *(reference: 0)*		
1	1.016 [0.774-1.333]	.908
2	0.961 [0.680-1.358]	.822

IMD *(reference: low)* *Intermediate* *High*	 1.087 [0.779-1.516] 1.235 [0.863-1.767]	 .624 .248
Level 2: Variance on School Level	.105 [.031-.355]	

Table 16: Comprehensive multilevel associations between built environmental characteristics, potential confounders and SLIC children's frequency of sports participation

Whereas strong associations were found between the built environment and SLIC children's mode of commuting to school, no single built environmental variable included in the individual models shows a significant association with SLIC children's self-reported frequency of participation in sports and exercise. Due to its more pronounced odds ratios, the distance to the nearest park or public garden is retained as the strongest proximity variable in the final model. Nonetheless, also for this comprehensive multilevel model including all six built environmental characteristics, the observation holds that no significant link between participants' objectively assessed neighbourhood characteristics and their extracurricular sports and exercise engagement can be established.

The provision of physical activity facilities close to the homes of SLIC children did not result in their increased frequency of participation in sports and exercise. While a limited number of studies concludes that the availability and proximity of public open space independently incites physical activity among children (Ding et al. 2011; Timperio et al. 2015), the findings for the SLIC children are in accordance with broader evidence demonstrating that the mere provision of places for children's sports, play and exercise is insufficient to stimulate this form of activity. Beyond availability and geographical accessibility, intrapersonal, social and environmental factors also influence children's access to and use of public spaces, which have context-specific qualities attributed to them by parents and children (Chaudhury 2017; Timperio et al. 2008). Parental perceptions and role modelling are particularly pivotal in negotiation this use (Yao & Rhodes 2015). Moreover, a child does not necessarily visit the closest activity space to her or his place of residence, but the space best suited to her or his highly individual needs and wishes (Chaudhury 2017; Timperio et al. 2008).

Beyond proximity, no significant associations are found for the relation between the frequency with which SLIC children participated in sports activities and traffic and personal risk in their home neighbourhoods. The limited number of studies that address objective measures of neighbourhood safety in relation to children's physical activity obtain scattered results, and often fail to unveil any independent impact on sports participation (An et al. 2017; Côté-Lussier et al. 2015). Moreover, prior research clearly demonstrates that perceptions of and concerns about traffic and crime safety, primarily those of parents, tend to be more decisive in determining the participation in outdoor activity than objective safety records (An et al. 2017; Lenhart et al. 2017). To fully grasp the role played by safety considerations in the decision-making processes regarding extracurricular sports and exercise, these subjective, experiential data need to be captured.

Analogously, objective levels of air quality in the home neighbourhood, serving as a proxy of local volumes of motorized traffic, do not appear as a significant correlate of this component of extracurricular physical activity for SLIC children. While the adverse consequences of air pollution on population health are uncontestably proven, research centred around its effect on the outdoor activity of children is largely absent (An et al. 2018). The few studies that have taken this aspect into account, mainly for adults and set in North America, are not in line with the findings for the SLIC sample, as they suggest an inverse relationship between a toxic ambient environment and residents' engagement in outdoor activities (An et al. 2018).

The relation between Stockton's Walkability Index scores and participants' engagement in the full range of gauged sports does not reach statistical significance either. Hence, the question remains whether this composite index calculated for healthy adults is appropriate to be used in children's activity studies. Prior research has failed to provide a definitive answer to this question (D'Haese et al. 2014; Gascon et al. 2016).

Similarly, convenience store density, the sixth and final included variable, is also found to be unrelated to SLIC pupils' more frequent sports engagement. This is in accordance with lack of consistent evidence on the effect of the foodscape on child activity in current literature (Burgoine et al. 2015; McGrath et al. 2016).

The structural absence of significant associations between built environmental variables and SLIC children's extracurricular sports and exercise participation could have various explanations. On the one hand, neighbourhood perceptions and parental role modelling could overrule the quantitatively ascertained quality of the physical environment. On the other, this form of activity is often set indoors or in a setting outside the immediate home neighbourhood. The combination of both could cancel out any potential direct effect of home surroundings. The go-along technique in the qualitative stage of this research presents an excellent opportunity to collect the contextualized data required to understand why the nearby provision and objective quality of facilities appear to be insufficient to get children moving.

Looking at potential confounders, the results for the comprehensive model show a significant, positive association for age in relation to participants' frequency of engagement in sports and exercise. The participation of children in this form of extracurricular physical activity as they grow older can be explained by their increasing cognitive abilities (Helbich 2017) and more regular partaking in organized sports activities, highly dependent on parental support (Kobel et al. 2015). Previous literature records a decrease in activity levels with age, though this decline is primarily observed from the onset of adolescence (Corder et al. 2016; Dumith et al. 2011).

The absence of a relation with sex, ethnicity, and family and neighbourhood socioeconomic status contrasts with the binary, exploratory statistics, as well as with prior research among UK primary schoolchildren. For the individual-level confounders, reviews studying the link between preadolescents' sex and activity find that boys tend to be more active than girls (Mitchell et al. 2016; Sterdt et al. 2014), a trend also observed in London (Purslow et al. 2008). In addition, studies show that South Asian kids tend to be less physically active than white boys and girls, especially due to their lower levels of after-school activity (Eyre et al. 2013; Smith et al. 2018a). Smith and colleagues (2018b) refer to the specific set of sociocultural boundaries experienced by South Asian parents living in the UK to explain their offspring's lower physical activity. In contrast, higher activity levels are observed for children of black ethnicity in comparison to their white peers (Eyre et al. 2013; Eyre & Duncan 2013). It should, however, be noted that these studies rarely explicitly control for family and neighbourhood socioeconomic status and seldom disentangle core activity components. Where they do, interethnic physical activity disparities are strongly reduced (Knowles 2014).

Prior research links higher socioeconomic status to greater sports participation. However, once again, this effect seems to only kick in during adolescence, as older youths participate less in informal sports and exercise, and increase their engagement in organized activities which are more time-consuming and require significant financial resources (Sterdt et al. 2014). Reviews of both quantitative and qualitative studies support the observation that family socioeconomic status is less decisive at younger ages (O'Donoghue et al. 2018; Sterdt et al. 2014). However, evidence for children in London identifies particularly high average physical activity levels in neighbourhoods of lower socioeconomic status in the capital, contrary to the UK trend noted above (Watts et al. 2013), and supported by later UK research (Pouliou et al. 2014). The null-findings in the present study therefore underline the complexity of these relations. The inconsistency of results for family and neighbourhood deprivation can, at least in part, be explained by the multidimensionality of both socioeconomic status and physical activity, and their complex methodological operationalization (O'Donoghue et al. 2018). However, the lack of significant associations for the breadth of socioeconomic variables included in the models for SLIC children demonstrates that a relation with extracurricular sports and exercise is unlikely for the included primary schoolchildren in London.

Summarising, while the limitations associated with the self-reported nature of this dependent variable should be stressed, the ability of these models to predict participants' participation in out-of-school sports and exercise is highly limited. This contrasts with the clear-cut relations found for the commuting component of children's extracurricular physical activity. With the exception of age, no included variable shows a significant association with this activity component for SLIC children. The reasons for this absence of significant findings for out-of-school sports and exercise participation will be explored in-depth in the qualitative stage of my explanatory sequential research.

ii. Step 2: Multilevel models linking SLIC children's extracurricular physical activity to their body composition

Having established the pathways by which the built environment impacts SLIC children's core extracurricular physical activity components, the associations between commuting to school and the frequency of sports participation and participants' body composition can now be explored. These will provide an answer to the second quantitative sub-question:

> *"Controlling for potential confounders, is the weight status of London primary schoolchildren related to their levels of extracurricular physical activity?"*

The exploratory analyses underlined the importance of disentangling physical activity and body composition components, an observation supported by the first step of the multilevel modelling study. Therefore, also in this second step linking extracurricular activity to body weight, results are discussed separately for both core component of participants' physical activity. The associations emerging from the multilevel mixed-effect ordered logistic models examining the relation of commuting to school with body composition are shown in *table 17. Table 18* then shows the link between self-reported out-of-school sports and exercise participation and BMI, FMI and FFMI.

Exploring the results for SLIC children's modes of commuting first, BMI data indicate that active school commuting is associated with lower odds of childhood overweight and obesity compared to passive commuting. Using the indexes of fat and fat-free mass, a similar finding is also obtained for FMI, but not for FFMI. Observations for mixed commuting and the disagreement category do not reach statistical significance.

When examining the findings for extracurricular sports and exercise engagement, participants who were active less than once a week have significantly lower odds of being overweight or obese compared to children who were active on a daily basis if only conventional BMI percentiles are taken into account. The higher odds ratios for completely inactive children to be overweight or obese do not reach the significance threshold for BMI. This picture changes, however, as soon as FMI and FFMI are studied. Children who were active less than weekly are significantly less likely to belong to high FFMI categories compared to daily active children, whereas the results for FMI do not attain statistical significance. A trend towards significance is also obtained for completely inactive children. They have higher odds of belonging to the highest FMI categories compared to children who engaged in sports and exercise every day. FMI and FFMI trends for other sports frequencies are similar to those for BMI.

Multilevel associations between SLIC children's BMI, FMI and FFMI, and their mode of commuting						
Variable	**BMI z-score percentile categories**		**ln(FMI) z-score percentile categories**		**FFMI z-score percentile categories**	
	Wald χ^2 *= 82.02; p < .001*		*Wald* χ^2 *= 46.21; p < .001*		*Wald* χ^2 *= 87.64; p < .001*	
Level 1	**OR [95% CI]**	**p-value**	**OR [95% CI]**	**p-value**	**OR [95% CI]**	**p-value**
Commuting mode *(reference: passive)*						
Mixed	0.471 [0.112-1.979]	.304	0.584 [0.099-3.463]	.554	0.751 [0.138-4.076]	.740
Active	**0.678 [0.531-0.865]**	**.002****	**0.679 [0.499-0.922]**	**.013***	0.918 [0.665-1.267]	.603
Disagreement	1.028 [0.769-1.375]	.850	0.994 [0.696-1.419]	.972	1.451 [0.998-2.110]	.051
Sex *(reference: female)*						
Male	0.856 [0.698-1.050]	.136	0.987 [0.763-1.275]	.918	1.085 [0.833-1.414]	.546
Age at test	**1.118 [1.049-1.191]**	**.001****	1.012 [0.935-1.095]	.770	1.034 [0.951-1.123]	.436
Ethnicity *(reference: white/other)*						
Black	**1.459 [1.104-1.927]**	**.008****	**1.698 [1.191-2.420]**	**.003****	**1.547 [1.084-2.209]**	**.016***
South Asian	**0.606 [0.453-0.813]**	**.001****	1.302 [0.924-1.837]	.132	**0.248 [0.153-0.401]**	**<.001*****
Family Affluence Scale *(reference: low)*						
Moderate	1.093 [0.738-1.618]	.658	1.208 [0.737-1.981]	.453	1.382 [0.827-2.307]	.217
High	1.024 [0.641-1.638]	.920	1.574 [0.875-2.832]	.130	**1.888 [1.026-3.474]**	**.041***
Free school lunches *(reference: no)*						
Yes	**1.412 [1.078-1.851]**	**.012***	**1.633 [1.178-2.265]**	**.003****	**1.534 [1.081-2.177]**	**.017°**
Cars owned *(reference: 0)*						
1	0.961 [0.727-1.269]	.777	1.008 [0.713-1.426]	.964	0.990 [0.691-1.417]	.955
2	0.978 [0.679-1.409]	.904	0.819 [0.515-1.300]	.397	0.664 [0.407-1.082]	.100
Multiple Deprivation Index *(ref.: low)*						
Intermediate	1.265 [0.910-1.760]	.162	1.132 [0.747-1.714]	.559	1.317 [0.849-2.043]	.219
High	**1.407 [1.010-1.961]**	**.043***	1.417 [0.949-2.116]	.089	1.332 [0.846-2.097]	.216
Level 2: Variance on School Level	0.045 [0.009-0.210]		0.036 [0.005-0.291]		0.092 [0.019-0.441]	

Table 17: Multilevel associations between SLIC children's BMI, FMI and FFMI, and their mode of commuting

Multilevel associations between SLIC children's BMI, FMI and FFMI, and their frequency of sports and exercise participation						
Variable	**BMI z-score percentile categories**		**ln(FMI) z-score percentile categories**		**FFMI z-score percentile categories**	
	Wald χ^2 = 77.92; p < .001		*Wald χ^2 = 85.47; p < .001*		*Wald χ^2 = 85.47; p < .001*	
Level 1	**OR [95% CI]**	**p-value**	**OR [95% CI]**	**p-value**	**OR [95% CI]**	**p-value**
Sports Frequency *(reference: daily)*						
Never	2.222 [0.977-5.052]	.057	2.485 [0.961-6.429]	.060	1.816 [0.619-5.328]	.277
Less than weekly	**0.435 [0.236-0.802]**	**.008****	0.466 [0.210-1.341]	.061	**0.455 [0.214-0.969]**	**.041****
Weekly	0.970 [0.750-1.256]	.819	0.967 [0.697-1.341]	.841	0.945 [0.676-1.321]	.741
Most days	0.911 [0.707-1.174]	.471	0.998 [0.728-1.369]	.990	0.832 [0.596-1.162]	.281
Sex *(reference: female)*						
Male	0.843 [0.687-1.035]	.102	0.975 [0.754-1.261]	.846	1.063 [0.815-1.386]	.654
Age at test	**1.110 [1.041-1.183]**	**.001****	1.005 [0.928-1.089]	.903	1.030 [0.947-1.120]	.486
Ethnicity *(reference: white/other)*						
Black	**1.563 [1.183-2.066]**	**.002****	**1.809 [1.268-2.580]**	**.001****	**1.612 [1.130-2.300]**	**.008****
South Asian	**0.607 [0.452-0.815]**	**.001****	1.306 [0.920-1.854]	.136	**0.253 [0.157-0.408]**	**<.001*****
Family Affluence Scale *(reference: low)*						
Moderate	1.209 [0.816-1.792]	.344	1.344 [0.818-2.209]	.244	1.491 [0.892-2.492]	.127
High	1.107 [0.692-1.771]	.671	1.728 [0.959-3.112]	.069	**1.940 [1.052-3.574]**	**.034***
Free school lunches *(reference: no)*						
Yes	**1.426 [1.087-1.870]**	**.010***	**1.681 [1.211-2.334]**	**.002****	**1.582 [1.114-2.247]**	**.010***
Cars owned *(reference: 0)*						
1	0.988 [0.749-1.305]	.934	1.040 [0.737-1.466]	.824	0.987 [0.690-1.411]	.941
2	1.052 [0.731-1.513]	.787	0.872 [0.550-1.381]	.559	0.674 [0.414-1.097]	.113
Multiple Deprivation Index *(reference: low)*						
Intermediate	1.275 [0.914-1.780]	.153	1.116 [0.735-1.696]	.607	1.318 [0.846-2.053]	.222
High	1.385 [0.979-1.960]	.066	1.384 [0.910-2.103]	.129	1.314 [0.828-2.085]	.246
Level 2: Variance on School Level	0.053 [0.012-0.227]		0.048 [0.008-0.298]		0.112 [0.026-0.479]	

Table 18: Multilevel associations between SLIC children's BMI, FMI and FFMI, and their frequency of sports and exercise participation

These findings, showing that active commuting to school is inversely associated with BMI, add to earlier research which has produced inconclusive evidence on the adiposity-countering effects of walking or cycling to school (Heelan et al. 2005; Masoumi 2017). Crucially, the disentanglement of BMI into its underlying fat and fat-free components in my study can clarify these relationships. When this is done, it becomes apparent that the inverse relationship obtained is principally due to lower FMI, and not FFMI, for active commuters, as previous studies looking specifically at adiposity suggested (Sarmiento et al. 2015; Sun et al. 2015).

Studying body composition also sheds light on the impact of sports and exercise participation. Frequent engagement in this type of activity does not consistently lower a child's likelihood of being overweight or obese as defined by BMI. A large body of studies prior to mine has generated inconsistent findings on this relationship (Cairney & Veldhuizen 2017). Whereas some studies find a BMI-lowering effect of sports throughout childhood and adolescence (Dunton et al. 2012; Quinto Romani 2011; Steiner et al. 2008), others find no relationship (Marques et al. 2016; Vella et al. 2013). Again, only when considering FMI and FFMI separately do the significant association between less-than-weekly sports participation and lower FFMI and the trend for completely inactive children to have higher fat masses emerge. The lower FFMI percentile scores for children who were active less than once a week are likely due to reduced muscle development (Hu 2008; Wells et al. 2002). Despite the more complex data collection process, it is thus indispensable to separately collect information on fat and fat-free mass.

These findings are independent of children's ethnicity, age, gender or socioeconomic status. Moreover, models combining both extracurricular physical activity components show that the observed effects are independent from each other, and that there are no significant interactions between them (results not shown).

Besides demonstrating the influence of physical activity components on primary schoolchildren's BMI, FMI and FFMI, the multilevel modelling results also expand the existing knowledge of confounding factors that affect body composition. Being younger is associated with lower weight status in terms of BMI, and no sex differences are obtained. In addition to these standard anthropometric variables, the multilevel models underline the mediating role played by ethnicity and socioeconomic status (El-Sayed et al. 2011; Ness et al. 2006). The analyses are able to address remaining uncertainties related to these confounders (El-Sayed et al. 2011) by looking at their effect on the same individuals for whom BMI, FMI and FFMI data are available. In terms of BMI, overall childhood overweight and obesity levels for the SLIC sample are comparable to those for primary schoolchildren at the national level, and slightly below the average for London (GLA 2011). However, the quantitative analyses unveil strong interethnic differences. Higher BMI childhood overweight and obesity rates are observed for black children, and lower rates for South Asians, in comparison to the white/other group. Using FMI, levels for children of black ethnicity are still consistently higher than those for any other ethnic group. Whilst not significant, the multilevel models show that South Asians also appear more likely to be in the highest adiposity category than whites/others, thereby supporting the binary statistics. Their lower BMI is therefore in first instance related to their significantly lower fat-free mass development.

The broad range of included family and neighbourhood socioeconomic confounders further elucidates the ethnicity-body composition relationship, as children of different ethnicities have previously been found to be unequally exposed to socioeconomic and environmental obesity risk factors (Chi et al. 2017; Kimbro & Denney 2013; Taveras et al. 2010). However, using multivariate models to correct for the association of ethnicity and family and neighbourhood socioeconomic variables, the significant association of ethnicity with body composition was found to be independent of socioeconomic conditions. Indeed, similar results for ethnicity are obtained in multilevel models in which socioeconomic status variables are in- or excluded. Black ethnicity retains its significant association with higher total, fat and fat-free body mass indices, and South Asian ethnicity with lower total and fat-free body mass compared to white/other children. This independent link between ethnicity and childhood overweight and obesity is in line with other research in the UK and elsewhere finding ethnic differences to be only partially explained by socioeconomic characteristics (Achat & Stubbs 2014; Zilanawala et al. 2015).

These results have several broader implications. First, most relevant associations would not have emerged if only BMI had been studied. Even stronger, healthy muscle mass, rather than excess body fat, might make frequently active children appear overweight or obese when BMI is used, as has been previously suggested (Hu 2008; Wells et al. 2002). Additionally, this measure is influenced by ethnicity, making the use of accurate anthropometric data and a wide range of socioeconomic characteristics indispensable in the study of childhood overweight and obesity.

Second, the multilevel models demonstrate how the core extracurricular physical activity components differently predict body composition for the multi-ethnic population of SLIC children from varying socioeconomic backgrounds. The observation that active commuting is linked to lower FMI is particularly relevant, given that adiposity has been shown to directly impact the short- and long-term morbidity and mortality of children with overweight and obesity (Reilly & Kelly 2011; Sahoo et al. 2015). The results thus contribute to the development of tailor-made policies to counter childhood overweight and obesity. They suggest that future interventions could be particularly promising if they consist of a combination of bold, structural changes to the built environment fostering active commuting to lower FMI, and the enabling of sports and exercise participation to raise FFMI. Disentangling the core variables of the childhood overweight and obesity-physical activity relationship is thus indispensable for the development of informed policy measures that can contribute to the reversal of the childhood overweight and obesity epidemic. Notwithstanding their more complex data collection process, fat and fat-free body mass data need to be separately collected to fully understand observed weight status trends, and anthropometric characteristics and socioeconomic status need to be corrected for. The same applies to physical activity: like in the first step, this overall variable needs to be disaggregated into its constituent components when its relationship with body composition is studied. The continuous omission of this disentanglement is likely to contribute to the substantial and growing body of literature describing counterintuitive and null-findings.

iii. Direct link: Multilevel models linking the built environment to SLIC children's body composition

The two prior, individual steps shed valuable light on the dynamics at work in the triad tying together children's objectively assessed neighbourhoods, their physical activity, and body composition. Myriad prior studies have, however, set out in search of a direct link between children's physical environments and body composition, resulting in a plethora of ambiguous findings. In an attempt to disentangle this evidence, the final quantitative sub-question is now addressed:

> *"Controlling for potential confounders, which built environmental characteristics are directly related to the weight status of London primary schoolchildren, starting from a predefined set of elements based on the extensive literature review and controlling for extracurricular physical activity?"*

Answering this question can also shed light on the residual effect built environmental characteristics have on SLIC children's propensity to develop excess adipose tissue via pathways other than inciting changes in physical activity behaviour, for instance through an impact on diet or through gene-environment interactions (Campbell 2018).

The question is addressed through the final set of multilevel models, directly relating the six included built environmental variables to SLIC children's body composition components. Participants' physical activity components, hypothesised to be potential mediators in this relation, and potential individual, family and neighbourhood socioeconomic confounders are accounted for. Given the strength of the associations between the characteristics of the road environment along the way to school and SLIC children's physical activity levels, these characteristics are retained for the models.

Adhering to the structure used for the formal data modelling in the first step, *table 19* shows the link between the average and extreme values for each individual built environmental characteristic along the shortest route to school and SLIC children's body composition, fully corrected for physical activity and potential confounders. *Table 20* then displays the results of the fully-adjusted models for BMI, FMI and FFMI including the six environmental variables. In analogy to the decision-making process in the first step, the choice to select a specific proximity variable and to include either the average or extreme value for each built environmental characteristic in the comprehensive models was made depending on the strength and significance of their independent associations with body composition in the individual models.

Multilevel associations between individual built environmental characteristics and SLIC children's BMI, FMI and FFMI						
Body Composition Variable	**BMI z-score categories**		**ln(FMI) z-score categories**		**FFMI z-score categories**	
Built Environmental Variable	***OR [95% CI]***	***p-value***	***OR [95% CI]***	***p-value***	***OR [95% CI]***	***p-value***
Proximity to School	*Wald χ^2 = 96.7*	*<.001*	*Wald χ^2 = 55.4*	*<.001*	*Wald χ^2 = 98.2*	*<.001*
Shortest route distance to school (m) - reference: <500.0						
500.0-999.9	1.188 [0.792-1.781]	.403	1.262 [0.754-2.113]	.375	1.148 [0.675-1.953]	.611
1,000.0-1,499.9	1.403 [0.928-2.123]	.108	1.290 [0.761-2.187]	.345	1.596 [0.928-2.747]	.091
≥ 1,500.0	1.196 [0.794-1.801]	.392	1.135 [0.673-1.914]	.635	1.521 [0.891-2.598]	.125
Proximity to Nearest Sports Facility	*Wald χ^2 = 94.5*	*<.001*	*Wald χ^2 = 53.5*	*<.001*	*Wald χ^2 = 96.2*	*<.001*
Shortest route distance (m) - reference: <500.0						
500.0-999.9	1.133 [0.701-1.832]	.611	1.009 [0.547-1.862]	.977	1.295 [0.682-2.456]	.429
1,000.0-1,499.9	1.291 [0.791-2.107]	.306	1.076 [0.579-2.000]	.817	1.448 [0.757-2.771]	.264
≥ 1,500.0	1.165 [0.719-1.889]	.535	1.022 [0.551-1.894]	.945	1.505 [0.792-2.859]	.212
Proximity to Nearest Park or Public Garden	*Wald χ^2 = 96.2*	*<.001*	*Wald χ^2 = 56.4*	*<.001*	*Wald χ^2 = 97.9*	*<.001*
Shortest route distance (m) - reference: <500.0						
500.0-999.9	1.178 [0.902-1.539]	.228	1.176 [0.839-1.650]	.347	1.286 [0.904-1.830]	.161
1,000.0-1,499.9	1.046 [0.763-1.434]	.780	1.185 [0.798-1.761]	.400	1.374 [0.911-2.072]	.130
≥ 1,500.0	0.805 [0.501-1.294]	.371	0.750 [0.400-1.404]	.368	0.891 [0.443-1.559]	.564
Average Traffic Risk along Route	*Wald χ^2 = 97.9*	*<.001*	*Wald χ^2 = 55.3*	*<.001*	*Wald χ^2 = 96.9*	*<.001*
Average accident rate per 10^4 inhabitants crossed - reference: <20.0						
20.0-39.9	1.089 [0.849-1.397]	.504	1.006 [0.736-1.375]	.972	1.108 [0.801-1.532]	.537
≥ 40.0	**1.453 [1.021-2.069]**	**.038***	1.422 [0.927-2.182]	.107	**1.695 [1.068-2.689]**	**.025***
Maximum Traffic Risk along Route	*Wald χ^2 = 96.3*	*<.001*	*Wald χ^2 = 53.8*	*<.001*	*Wald χ^2 = 99.2*	*<.001*
Highest accident rate per 10^4 inhabitants crossed - reference: <20.0						
20.0-39.9	1.287 [0.818-2.026]	.275	1.082 [0.619-1.892]	.782	1.039 [0.573-1.884]	.900
≥ 40.0	1.449 [0.942-2.229]	.091	1.162 [0.686-1.968]	.577	1.504 [0.862-2.626]	.151
Average Personal Risk along Route	*Wald χ^2 = 92.6*	*<.001*	*Wald χ^2 = 54.0*	*<.001*	*Wald χ^2 = 93.6*	*<.001*
Average crime rate crossed - reference: <90.0						
90.0-109.9	1.202 [0.815-1.771]	.353	1.232 [0.774-1.962]	.378	1.240 [0.730-2.108]	.427
≥ 110.0	1.057 [0.750-1.488]	.752	0.975 [0.643-1.477]	.903	1.151 [0.705-1.879]	.574
Maximum Personal Risk along Route	*Wald χ^2 = 98.6*	*<.001*	*Wald χ^2 = 63.3*	*<.001*	*Wald χ^2 = 93.8*	*<.001*
Highest crime rate crossed - reference: <90.0						
90.0-109.9	0.682 [0.424-1.098]	.115	0.634 [0.343-1.169]	.144	1.050 [0.558-1.977]	.879
≥ 110.0	1.030 [0.762-1.392]	.847	1.223 [0.852-1.756]	.275	1.309 [0.865-1.979]	.202

Average Air Pollution along Route	*Wald χ^2 = 93.3*	*<.001*	*Wald χ^2 = 52.5*	*<.001*	*Wald χ^2 = 94.3*	*<.001*
Average Combined Emission Index crossed - reference: <90.0						
90.0-109.9	1.253 [0.889-1.767]	.198	1.388 [0.878-2.192]	.160	0.927 [0.591-1.453]	.741
≥ 110.0	1.209 [0.759-1.927]	.424	1.477 [0.803-2.715]	.209	1.060 [0.576-1.952]	.852
Maximum Air Pollution along Route	*Wald χ^2 = 93.1*	*<.001*	*Wald χ^2 = 54.1*	*<.001*	*Wald χ^2 = 93.4*	*<.001*
Highest Combined Emission Index crossed - reference: <90.0						
90.0-109.9	0.831 [0.575-1.201]	.325	0.994 [0.621-1.591]	.981	1.045 [0.627-1.744]	.865
≥ 110.0	0.929 [0.598-1.444]	.743	0.936 [0.528-1.661]	.822	1.346 [0.717-2.527]	.355
Average Walkability along Route	*Wald χ^2 = 102.9*	*<.001*	*Wald χ^2 = 59.4*	*<.001*	*Wald χ^2 = 97.8*	*<.001*
Average quintile crossed - reference: 1 (least walkable)						
2	**1.741 [1.131-2.680]**	**.012***	**1.963 [1.134-3.399]**	**.016***	1.303 [0.723-2.348]	.378
3	**1.724 [1.076-2.763]**	**.024***	**1.881 [1.037-3.412]**	**.038***	1.300 [0.660-2.562]	.448
4	**2.206 [1.300-3.743]**	**.003****	**2.004 [1.033-3.888]**	**.040***	1.524 [0.731-3.181]	.261
5 – Most walkable	**2.321 [1.131-4.760]**	**.022***	2.160 [0.899-5.188]	.085	1.085 [0.413-2.850]	.868
Minimum Walkability along Route	*Wald χ^2 = 99.3*	*<.001*	*Wald χ^2 = 55.3*	*<.001*	*Wald χ^2 = 99.5*	*<.001*
Lowest quintile crossed - reference: 1 (least walkable)						
2	1.185 [0.878-1.599]	.266	1.056 [0.727-1.535]	.774	1.149 [0.779-1.694]	.483
3	1.383 [0.939-2.037]	.101	1.264 [0.797-2.006]	.320	1.170 [0.716-1.912]	.531
4	0.848 [0.453-1.588]	.606	0.807 [0.375-1.739]	.585	0.601 [0.262-1.381]	.231
5 – Most walkable	2.288 [0.490-10.684]	.293	1.464 [0.191-11.228]	.714	3.012 [0.530-17.112]	.214
Average Foodscape Density along Route	*Wald χ^2 = 97.4*	*<.001*	*Wald χ^2 = 63.9*	*<.001*	*Wald χ^2 = 92.1*	*<.001*
Average convenience stores/mile^2 crossed - reference: ≤20						
21-50	1.127 [0.644-1.973]	.676	0.862 [0.443-1.677]	.661	1.276 [0.579-2.811]	.545
51-80	1.201 [0.593-2.434]	.611	0.816 [0.345-1.930]	.643	1.704 [0.610-4.761]	.309
> 80	0.868 [0.447-1.687]	.676	0.499 [0.227-1.096]	.083	1.729 [0.648-4.612]	.274
Maximum Foodscape Density along Route	*Wald χ^2 = 95.7*	*<.001*	*Wald χ^2 = 66.0*	*<.001*	*Wald χ^2 = 92.7*	*<.001*
Highest convenience stores/mile^2 crossed - reference: ≤20						
21-50	1.094 [0.474-2.524]	.833	0.692 [0.269-1.779]	.444	1.098 [0.432-3.524]	.875
51-80	1.249 [0.530-2.944]	.611	1.000 [0.372-2.687]	.999	1.219 [0.371-4.006]	.744
> 80	0.896 [0.370-2.169]	.808	0.507 [0.184-1.399]	.189	1.299 [0.381-4.425]	.676

Table 19: Multilevel associations between individual built environmental characteristics and SLIC children's BMI, FMI and FFMI

Comprehensive multilevel associations between built environmental characteristics, potential confounders and SLIC children's BMI, FMI and FFMI						
Body Composition Variable	**BMI z-score categories**		**ln(FMI) z-score categories**		**FFMI z-score categories**	
Built Environmental Variable	*Wald χ^2 = 128.9; p < .001*		*Wald χ^2 = 83.6; p < .001*		*Wald χ^2 = 103.5; p < .001*	
Level 1	***OR [95% CI]***	***p-value***	***OR [95% CI]***	***p-value***	***OR [95% CI]***	***p-value***
Proximity to School						
Shortest route distance (m) - reference: <500.0						
500.0-999.9	1.094 [0.723-1.655]	.670	1.059 [0.625-1.795]	.831	1.143 [0.662-1.975]	.632
1,000.0-1,499.0	1.330 [0.866-2.042]	.192	1.062 [0.615-1.832]	.830	1.661 [0.943-2.927]	.079
≥ 1,500.0	1.057 [0.681-1.640]	.806	0.825 [0.472-1.441]	.500	1.451 [0.815-2.583]	.206
Average Traffic Risk along Route						
Average accident rate per 10^4 inhabitants crossed - reference: <20.0						
20.0-39.9	1.062 [0.771-1.461]	.714	0.825 [0.560-1.216]	.332	1.058 [0.702-1.594]	.786
≥ 40.0	1.426 [0.936-2.173]	.098	1.172 [0.702-1.956]	.543	1.634 [0.942-2.834]	.080
Maximum Personal Risk along Route						
Highest crime rate crossed - reference: <90.0						
90.0-109.9	0.694 [0.412-1.169]	.170	0.909 [0.470-1.757]	.776	0.923 [0.451-1.887]	.826
≥ 110.0	0.903 [0.613-1.330]	.607	1.347 [0.857-2.117]	.197	1.139 [0.675-1.920]	.626
Average Air Pollution along Route						
Average Combined Emission Index crossed - reference: <90.0						
90.0-109.9	1.121 [0.791-1.588]	.522	1.225 [0.800-1.874]	.350	0.806 [0.478-1.361]	.420
≥ 110.0	1.085 [0.645-1.825]	.759	1.571 [0.836-2.952]	.161	0.757 [0.365-1.570]	.454
Average Walkability along Route						
Average quintile crossed - reference: 1 (least walkable)						
2	**1.791 [1.142-2.808]**	**.011***	**1.879 [1.064-3.318]**	**.030***	1.331 [0.687-2.577]	.397
3	1.619 [0.992-2.642]	.054	**1.892 [1.030-3.476]**	**.040***	1.065 [0.481-2.354]	.877
4	**2.244 [1.255-4.013]**	**.006****	**2.104 [1.008-4.392]**	**.048***	1.136 [0.458-2.818]	.783
5 – Most walkable	**2.274 [1.054-4.903]**	**.036***	2.216 [0.864-5.686]	.098	0.796 [0.262-2.419]	.687
Average Foodscape Density along Route						
Average convenience stores/mile^2 crossed - reference: ≤20						
21-50	0.922 [0.527-1.613]	.776	0.760 [0.379-1.526]	.440	1.336 [0.589-3.028]	.488
51-80	0.743 [0.346-1.598]	.447	0.483 [0.188-1.240]	.130	1.695 [0.538-5.344]	.368
> 80	0.629 [0.306-1.290]	.206	**0.310 [0.126-0.759]**	**.010***	2.105 [0.703-6.303]	.184

Commuting mode *(reference: passive)*						
Mixed	0.396 [0.092-1.701]	.213	0.487 [0.082-2.904]	.430	0.820 [0.145-4.629]	.822
Active	**0.656 [0.502-0.857]**	**.002****	**0.641 [0.459-0.896]**	**.009****	1.003 [0.705-1.427]	.986
Disagreement	1.003 [0.744-1.353]	.985	0.965 [0.669-1.393]	.850	**1.540 [1.046-2.269]**	**.029***
Sports Frequency *(reference: daily)*						
Never	2.137 [0.919-4.968]	.078	2.196 [0.835-5.777]	.111	1.519 [0.507-4.550]	.455
Less than weekly	**0.407 [0.220-0.753]**	**.004****	0.448 [0.200-1.006]	.052	**0.411 [0.193-0.878]**	**.022***
Weekly	0.976 [0.753-1.263]	.851	0.970 [0.699-1.346]	.855	0.959 [0.684-1.345]	.809
Most days	0.876 [0.677-1.133]	.312	0.973 [0.706-1.340]	.865	0.794 [0.566-1.114]	.182
Sex *(reference: female)*						
Male	0.845 [0.688-1.038]	.108	0.979 [0.756-1.268]	.872	1.074 [0.822-1.404]	.602
Age at test*; years from 5 to 11*	**1.117 [1.047-1.191]**	**.001****	1.008 [0.930-1.092]	.854	1.028 [0.944-1.119]	.528
Ethnicity *(reference: white/other)*						
Black	**1.502 [1.132-1.993]**	**.005****	**1.877 [1.310-2.689]**	**.001****	**1.612 [1.114-2.333]**	**.011***
South Asian	**0.636 [0.473-0.854]**	**.003****	1.423 [0.996-2.034]	.053	**0.272 [0.166-0.445]**	**<.001*****
Family Affluence Scale *(reference: low)*						
Moderate	1.195 [0.803-1.780]	.380	1.347 [0.817-2.220]	.243	1.465 [0.873-2.457]	.148
High	1.090 [0.678-1.751]	.722	1.675 [0.928-3.023]	.087	**2.033 [1.095-3.774]**	**.025***
Free school lunches *(reference: no)*						
Yes	**1.374 [1.040-1.816]**	**.025***	**1.634 [1.159-2.303]**	**.005****	**1.500 [1.041-2.160]**	**.030***
Cars owned *(reference: 0)*						
1	0.973 [0.734-1.290]	.850	1.034 [0.729-1.466]	.851	1.025 [0.712-1.476]	.895
2	0.977 [0.676-1.413]	.904	0.817 [0.512-1.303]	.396	0.679 [0.412-1.117]	.127
IMD *(reference: low)*						
Intermediate	1.128 [0.805-1.581]	.484	1.003 [0.652-1.544]	.990	1.238 [0.779-1.969]	.367
High	1.195 [0.798-1.790]	.388	1.310 [0.805-2.131]	.277	1.131 [0.654-1.958]	.659
Level 2: Variance on School Level	0.008 [0.000-2.020]		<.001 [<.001-<.001]		0.133 [0.020-0.904]	

Table 20: Comprehensive multilevel associations between built environmental characteristics, potential confounders and SLIC children's BMI, FMI and FFMI

In contrast to the clear associations, firstly, between SLIC children's built environment and physical activity, and, secondly, between this physical activity and participants' body composition, the evidence emerging from the direct link between the objectively measured neighbourhood and BMI, FMI and FFMI is much sparser. The individual models show a significant and positive associations for only two variables. On the one hand, SLIC children commuting along routes with the highest average traffic risk have an increased likelihood to fall in the highest BMI and FFMI categories. On the other, participants' higher average walkability of the road environment entails higher odds of being confronted with overweight or obesity, both measured by BMI and FMI.

These relations appear to be counterintuitive, and contrast with what was found for the step-by-step analyses. While the findings for traffic safety and BMI are in accordance with prior evidence (An et al. 2017), the disentanglement of the fat- and fat-free components highlights that this higher body weight might be driven by children's stronger muscle development. As An and colleagues (2017) suggest, the pathway via physical activity is thus crucial. The positive association between the adult-centred Walkability Index and children's adiposity once again emphasises that combining residential density, street connectivity and land use mix might not be suitable, and indeed contrary, to what constitutes a walkable road environment for children (Helbich 2017). Though several studies describe a negative association between composite walkability indices and children's weight status, the results from the multilevel modelling in this study add to the overall inconclusive evidence on this relation (Casey et al. 2014; Galvez et al. 2010).

Contrasting with the binary statistical analyses, the four remaining built environmental variables do not show significant associations with BMI, FMI or FFMI in the individual multilevel models. The lack of any direct effect of proximity to neighbourhood facilities, personal safety, air pollution and the density of convenience stores on body composition could be explained by the dominance of the physical activity pathway. Moreover, children from more affluent socioeconomic backgrounds are likely to live closer to neighbourhood facilities, in areas with lower crime levels, lower densities of unhealthy food outlets, and better air quality – a phenomenon described as 'deprivation amplification' (Brook & King 2017; Cetateanu & Jones 2014; Macintyre et al. 2008; Sutherland et al. 2013). Controlling for socioeconomic status in the multivariate analyses therefore disentangles the complex relation between deprivation and remoteness, crime, air pollution and food exposure (Cetateanu & Jones 2014; Eime et al. 2015; Jerrett et al. 2014), highlighting that the effect of the former might be stronger in determining the body composition of SLIC children. In addition, perception and parental role modelling could predominate over objective measures (An et al. 2017; Timperio et al. 2015). The qualitative stage will serve to elucidate these subjective aspects.

Given their more clearly defined odds ratios and stronger trends towards significance in the individual models, proximity to school, the average values along the route for traffic risk, air pollution, walkability and the foodscape, as well as the extremes of personal risk were retained for inclusion in the comprehensive model. While walkability maintains its significance with body composition, the significant associations for traffic risk disappear. In contrast, bringing the six built environmental characteristics together to study their relative contribution to SLIC children's BMI, FMI and FFMI, a new relation appears for the foodscape. In comparison to pupils commuting along routes with the lowest average exposure to unhealthy food stores, a density of convenience stores of over 80 outlets/mile^2 during the commute is significantly associated with lower adiposity among study participants. This contrasts with the limited prior evidence linking the density of this type of food outlets to increased levels of overweight and obesity (Casey et al. 2014). It should, however, be noted that these studies relied on BMI as the metric for excess weight. The associations for proximity, personal safety and air pollution remain insignificant.

The comprehensive multilevel model supports the hypothesis that the absence of an unequivocal, direct link between the built environment and children's body composition is due to the crucial role played by physical activity in mediating this relationship. Indeed, the associations between the commuting choices and sports participation and the BMI, FMI and FFMI of SLIC children discussed in the second step retain their significance. The conceptualisation of the triad connecting the built environment, children's physical activity and body composition as a two-step chain thus proves to be both more accurate and insightful than a simple, linear link between children's neighbourhood characteristics and their weight status. As the inclusion of the physical activity variables in these models is the only statistical method of ascertaining their mediating role included here, and their exclusion from direct models indicates partial rather than full mediation, these results should of course be interpreted with caution. The potential individual, family and neighbourhood socioeconomic confounding characteristics follow the same patterns as discussed in the second step, linking physical activity to body composition. This supports the deprivation amplification argument, and builds a strong case for a joint physical activity-socioeconomic status pathway connecting children's neighbourhood characteristics with their weight status outcomes.

c. Key takeaways from the multilevel modelling

The multilevel models for the two-step chain linking features of the home neighbourhood and road environment of SLIC children to their levels of overweight and obesity revealed the existence of built environmental barriers to, and facilitators of, participants' core physical activity components. At the same time, they explicated the impact this activity has on their body composition. The first step showed that the objectively assessed environment is more strongly related to children's choice of a mode of commuting than to their participation in extracurricular sports or exercise. Proximity and traffic safety emerged as the key environmental variables related to children's active commuting to school, and should therefore be the foci of activity-enhancing policy and interventions. This is further enhanced by the observation from the second step that this active commuting could play a vital role in reducing children's adiposity levels.

The findings support Townshend and Lake's (2017) argument that there is enough proof to implicate the built neighbourhood as a culprit in rising levels of childhood adiposity. However, this was only visible once patterns of physical activity and body composition were disentangled, and BMI, used as a measure of childhood overweight and obesity all too often, was discarded. The lack of disentanglement in prior research is a main reason for the consistently inconsistent evidence obtained. Whilst a limited direct effect between built environment and body composition could be observed, the multilevel models suggest that the role of physical activity as a mediator in this relation is essential, and more decisive than the foodscape in children's local neighbourhood. On its own, the built environment has little independent weight in determining overweight and obesity levels for the SLIC children in

London. However, through their impact on physical activity, children's everyday spatialities and their infrastructural characteristics proved to be core determinants of body composition.

V. Key takeaways from the quantitative research stage

Using cartography to gain insight into the spatial patterning of potential built environmental drivers of, and barriers to, children's physical activity and body composition, and underpinning the resulting visual evidence with binary and multivariate statistics, I was able to formulate a comprehensive answer to my first, quantitative central research question.

Place, conceptualized as a spatiality, unequivocally influences SLIC children's body composition in London. This implicates the built environment in the epidemic of childhood overweight and obesity. This effect is, however, mainly observed through the potential of neighbourhood characteristics to foster or hinder children's physical activity which, in turn, has an independent effect on their body composition. This importance of physical activity as a potential centre point in reversing the childhood overweight and obesity epidemic is further strengthened by the weaker associations between the foodscape around participants' homes and schools and their fat or fat-free mass. The pivotal role of children's activity levels in the ecology of overweight and obesity can therefore not be underestimated.

Proximity emerged as the dominant factor influencing children's decision whether or not to walk or cycle to school, with children residing close to school being more likely to actively commute. Nonetheless, personal and road safety and the provision of a healthy environment in terms of food options and air pollution along the route to school all showed significant associations as well, thereby requiring the attention of urban planners and policymakers. Contrasting with this strong influence on commuting decisions, SLIC children's self-reported frequency of sports and exercise participation was less clearly related to the objectively assessed built environment around the home. Moreover, when total extracurricular activity of SLIC children was disentangled into its prime components, active commuting appeared to be related to lower adiposity, whereas frequent participation in sports was associated with greater fat-free mass accretion.

As the reduction of children's fat masses is the key focus of policies and interventions aimed at reducing levels of overweight and obesity, raising the share of actively commuting pupils thereby emerges as the main intervention target. Given its availability and benefits to all children, both to those with and without excess weight, as well as to the wider community, inciting active school travel could thus play a pivotal role in lowering children's adiposity in a non-stigmatizing, non-discriminatory and inexpensive manner. Bold steps are required, going beyond the simple promotion of this form of activity. Indeed, the built environment needs to be re-shaped to accommodate safe and enjoyable active commuting for children. The inclusion of confounders pointed out that both children from wealthy families and black SLIC participants tend to engage less in walking or cycling to school compared to their peers, demonstrating the great obesity-reducing potential of well-designed, population-wide active commuting interventions. These could then be complemented with the stimulation of outdoor sports participation, which could entail children's stronger muscle development. The cartography clearly highlighted the geographic areas that should be the focus of action to reduce activity and obesity inequities across the city, as the health benefits for children active in polluted, deprived and unsafe neighbourhoods are lower than for those living in more residential environments.

Not only did the quantitative analyses thus provide an insightful and policy-relevant answer to the central quantitative research question, they also addressed two prime flaws identified in the literature review on this topic that need immediate addressing. These flaws are likely to have contributed to the mixed outcomes in the reviewed prior evidence on the explored triad, as well as to the shortcomings and ineffectiveness of current childhood obesity policies. Firstly, by abandoning BMI and disentangling body composition components, black children were found to have significantly stronger muscle development compared to children of other ethnicities. Whilst they were still more prone to have elevated fat masses, looking at adiposity separately, their rates of overweight and obesity were lower than those for BMI. In contrast, overweight and obesity among South Asian children was underestimated, as their lower BMIs were, at least in part, due to their lower fat-free mass in comparison to children of other ethnicities. Aside from invalidating research that solely uses BMI as a measure of weight status, this finding calls for ethnicity-specific policies to address children's adiposity. Secondly, a similar flaw is engrained in the use of overall measures of physical activity in relation to body composition. Separating the commuting and sports and exercise components of children's extracurricular activity showed that both are associated with vastly different effects on the fat and fat-free mass of primary schoolchildren which would have remained obscured should an overall activity metric have been used.

In sum, the results for SLIC children show that adopting a classic, three-step Health Geographical research protocol enables a comprehensive insight into the objectively measurable dynamics at work in the triad of the built environment, physical activity and body composition. Combining data visualization with in-depth statistical analyses, evidence was obtained that could inform policy and delineate foci of future interventions to increase the physical activity of primary schoolchildren during the school year. The key findings for these quantitative analyses have also been published in peer-reviewed journal articles (Bosch et al. 2019, 2020), attached as *Appendices 3* and *4*.

At all times, however, the non-causality of these findings should be stressed, as should the role of individual and socioeconomic conditions in influencing the weight status of SLIC children, the time mismatch between built environmental variables and the subjective nature of the activity data, collected through self-reporting. The obtained results should therefore be interpreted with caution. The lack of small-scale, contextualized data was a clear shortcoming in the attempt to arrive at a full understanding of the observed, and sometimes counterintuitive trends, as well as those that were not observed. These core limitations strengthen the need for a mixed-methods approach to formulate a complete answer to the question of what drives the childhood overweight and obesity epidemic in London. Hence, the qualitative research stage is designed to gather these subjective data at the level of the daily lifeworld of individual children in London, complemented by more disaggregated, objective information on their daily physical activity, addressing the potential bias resulting from the self-reported SLIC activity data. Moreover, the impact of the presence of siblings and peers, parental and school attitudes to physical activity and seasonality can be unravelled. This holds the promise to help elucidate the remaining questions that arise from the quantitative stage, and deliver key building blocks for the development of local, context-specific and socially differentiated childhood physical activity and overweight and obesity policies and interventions.

Chapter 6: Collecting Qualitative Lived Experiences

I. Chapter introduction

In the first research stage, the objective dynamics at work in the triad linking the built environment to children's physical activity and body composition in London were established. The second stage of the exploratory sequential mixed-methods design can now be used to extend these quantitative findings, and to provide an in-depth understanding of the mechanisms underlying the associations identified through spatial epidemiology (Creswell et al. 2011). This second stage aims to answer the central qualitative research question: *"How do London primary schoolchildren, with and without overweight or obesity, experience and use characteristics of their built environment from an energy-expenditure perspective?"*

Combining go-along interviews, accelerometry and activity diaries, a rich set of data can be gathered that has the potential to provide insights into children's subjective lived experiences in their multiple and fluid built environments, supported by an abductive thematic data analysis strategy. These insights are presented in this chapter, consisting of six sections. Following this introduction, the second section substantiates the choice of three schools included in this study, and introduces the selected sample of participating schoolchildren. Next, the accelerometry and activity diary data are jointly displayed and interpreted, providing a quantitative overview of participants' physical activity levels throughout a regular school week. Fourth, the determinants of these real-life, real-time activity patterns are explored through the results of the abductive thematic go-along interview analyses. This section presents both the findings related to the deductively established themes addressing the vertices of the ecological framework, as well as novel inductive topics emerging from the fieldwork to be fitted in these vertices that explain the observed activity outcomes for included children. Given the importance of distinguishing the various physical activity components, the built environmental effects on active commuting and outdoor recreation are discussed separately. Fifth, the findings from interviews, accelerometry and activity diaries are collectively discussed, and policy suggestions emerging from children's narratives produced. Finally, the key takeaways from this qualitative study are highlighted before moving on to compare, contrast, integrate and triangulate these findings with those from the spatial epidemiological study in the next chapter.

II. Selected schools and participants

As highlighted in the methods chapter (chapter 4), both schools and participating primary schoolchildren were selected using a maximum variation sampling strategy, in order to gain a wide diversity of views from children of differing age, sex, ethnicity, socioeconomic status, geographic home location and body shape (Palinkas et al. 2015). This allows a state of saturation of salient, meaningful themes to swiftly arise from the interviews (Hennink et al. 2017). To that end, three schools were selected based on their strategic location in London: two in the Borough of Brent, Northwest London, and one in the Borough of Newham, East London (see *map 1* in the previous chapter for the location of these Boroughs). Brent, home to 34,000 children of primary school age (ONS 2020), claims the second spot of all London Boroughs in terms of BMI-assessed childhood overweight and obesity at reception age, with 26.0% of children having excess weight at the start of primary school (Department of Health 2020b). This figure increases to 41.5% by Year 6, fourth of all London Boroughs. Newham, with 38,000 resident boys and girls attending primary school (ONS 2020), does slightly better at reception age, ranking ninth of the 32 London Boroughs at 23.2%, but performs significantly worse for Year 6 pupils. At 42.9%, only ten- and eleven-year-olds in Barking and Dagenham have higher levels of unhealthy weight (Department of Health 2020b). The sheer scale of this issue is illustrated by *figures 13* and *14*.

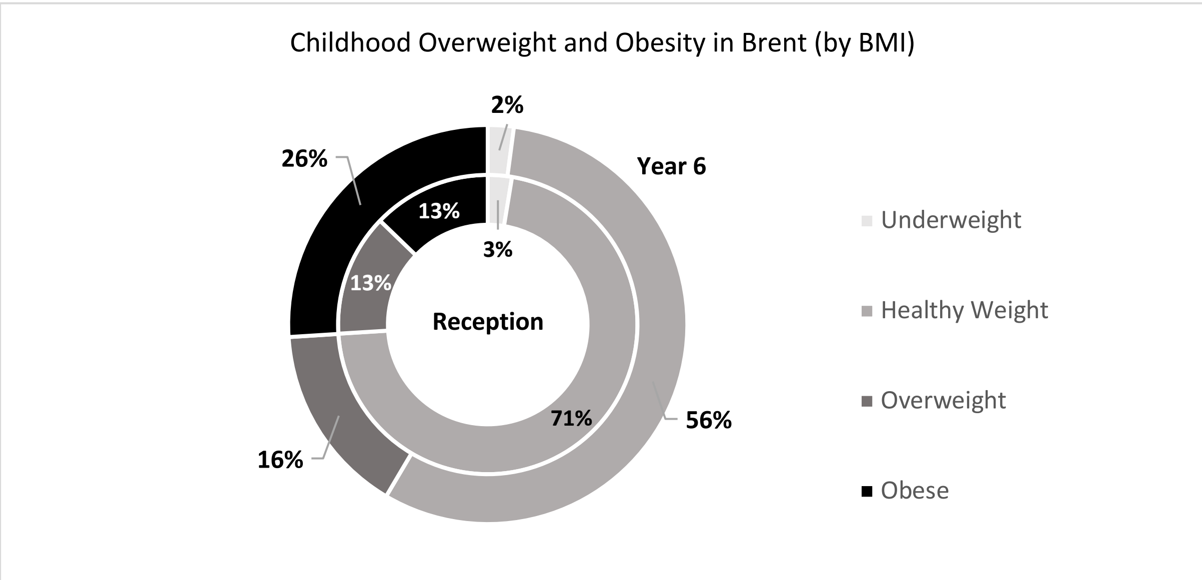


Figure 13: Childhood Overweight and Obesity in Brent

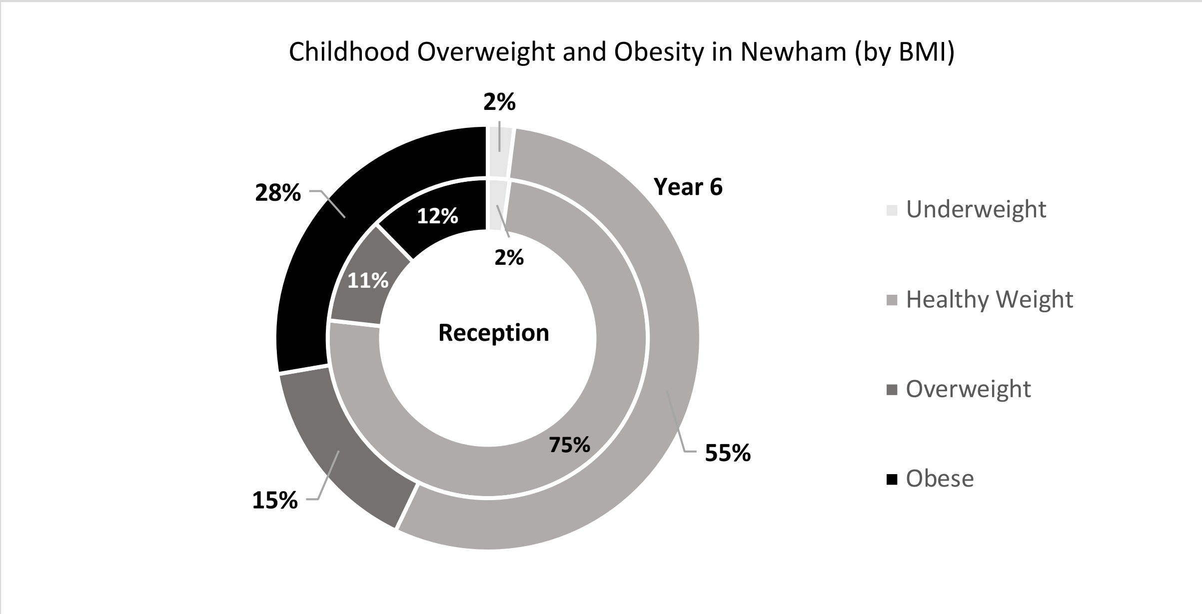


Figure 14: Childhood Overweight and Obesity in Newham

In addition to these high levels of overweight and obesity, the population of primary schoolchildren in these Boroughs is also highly ethnically diverse, further increasing their appropriateness for inclusion in this study. In Brent, 70.8% of pupils are non-white. In Newham, this share of minority-ethnic pupils is even larger, at 80.6% (Department of Health 2020a). In both Boroughs, about a fifth of students attending primary school are black, and the percentages of pupils of Asian ancestry are 29.9% and 48.8% in Brent and Newham respectively (Department of Health 2020a). Moreover, large socioeconomic disparities are also observed within the selected Boroughs. According to the 2019 Index of Multiple Deprivation, Newham ranks twelfth out of all 317 Local Authorities in England in terms of population deprivation, whereas Brent ranks 49th (Ministry of Housing, Communities and Local Government 2020). In addition to these statistics, the location of Newham in Inner London and Brent in Outer London according to the Office for National Statistics delineation adds to the diversity and strength of the gained microlevel evidence on built environmental drivers of children's physical activity and adiposity.

In Brent, two community schools were selected, one on either side of the Bakerloo Underground and London Overground lines that run southeast to northwest through the Borough. In Newham, a Roman Catholic primary school that also participated in the SLIC study was selected, situated towards the south of the Borough. All three schools have great ethnic and socioeconomic diversity among their student body, with as high as 88% of pupils having

English as additional language in one school and between 9% and 20% of students receiving free school meals. In the selected schools in Brent, a significant proportion of BAME pupils had a South Asian or Arab background, whereas in Newham, the ancestry was predominantly black African or Eastern European. For reasons of confidentiality, reference to the publicly available data sources for these school statistics is not included here.

A total of 86 applications from children in Years 3, 4 and 5 were received across the three schools. From this group of self-selected applicants, through maximum variation sampling, a diverse interview sample of 60 pupils was selected. The breakdown of this sample by school is shown in *table 21*. 57 go-along interviews were eventually carried out, implying an attrition rate of 5% (n=3). The three selected pupils who could not be interviewed all attended the school in Newham. One parent could not be reached via the contact details they provided in the informed consent form, whereas two parent-child pairs did not show up at the set date, time and place for the go-along interview on the way home after school.

Go-Along Interview Sample Selection by School			
School	**School Newham**	**Brent School 1**	**Brent School 2**
Number of applications received	25	35	26
Number of participants selected (not selected)	25 (0)	19 (16)	16 (10)
Number of interviews carried out (attrition)	22 (3)	19 (0)	16 (0)
Total number of interviews carried out: n=57 (Total attrition: n=3, 5%)			

Table 21: Go-Along interview sample selection by school

Further descriptive sample statistics are presented in *table 22*. One out of five children were aged seven or eight at the time of the completion of their informed consent forms. Two-thirds of participating pupils were nine or ten years old, whereas one in ten were eleven years old at the time of their application to participate in the research. With 28 boys and 29 girls participating, both sexes were well-represented in the sample. 40% of participants identified as black, with just over one-fifth identifying as South Asian, and a similar share of pupils in the sample indicating they identified as white. The remaining 15% belonged to the 'mixed/other' category.

Go-Along Interview Sample Composition					
School	**School Newham**	**Brent School 1**	**Brent School 2**	**Total**	**Percentage of total**
Age at application					
7	3	0	0	3	5.2
8	4	3	3	10	17.6
9	4	12	7	23	40.4
10	8	3	4	15	26.3
11	3	1	2	6	10.5
Sex					
Male	10	10	8	28	49.1
Female	12	9	8	29	50.9
Ethnicity					
Black	20	1	2	23	40.4
South Asian	0	8	5	13	22.8
White	2	6	4	12	21.0
Mixed/Other	0	4	5	9	15.8
Interview Type					
Active Commute	11	7	6	24	42.1
Passive Commute – car	2	2	5	9	15.8
Passive Commute – public transport	4	5	1	10	17.6
Neighbourhood tour	5	5	4	14	24.5
Average Interview Duration (min)	**30**	**36**	**31**	**32**	
Active Commute	19	31	22	23	
Passive Commute – car	17	34	35	31	
Passive Commute – public transport	35	36	41	36	
Neighbourhood tour	53	42	36	44	
Average Interview Length (km)	**2.09**	**2.67**	**2.50**	**2.48**	
Active Commute	1.05	1.17	1.10	1.10	
Passive Commute – car	2.60	4.50	5.86	4.83	
Passive Commute – public transport	3.98	4.94	3.40	4.40	
Neighbourhood tour	2.64	1.76	1.38	1.96	

Table 22: Composition of the go-along interview sample

Looking at the type of interviews, some 40% of interviews performed were walk-alongs during the commute to or from school. These active commutes were on average just over one kilometre (km) in length – well within walking distance for children (D'Haese et al. 2011) – with a mean duration of 23 minutes. Passive commutes, making up one-third of all interviews, tended to be significantly longer in distance, transcending the 1.5km boundary for walking to destinations. Drive-alongs by private car spanned 4.8km and lasted half an hour on average. Commutes by public transport were similar in both length and duration, taking an average of 36 minutes to cross 4.4km. The remaining quarter of interviews were guided neighbourhood tours by the child. These routes were on average two kilometres in length, and were completed in just under 45 minutes. In total, 141.4 kilometres (87.9 miles) of London roads were crossed during the 57 go-along interviews, adding up to 30 hours and 16 minutes of collected interview data.

Interviews were carried out between October 2018 and February 2019 – the darkest, wettest and coldest months of the year. Performing interviews in the six months with the worst climatic conditions allowed the baseline activity and environmental experience of pupils to be established, as children have been shown to be significantly less active during autumn and winter months (Rahman et al. 2019).

As mentioned in the paragraph on ethics in the methods chapter, the interviews were accompanied by an adult related to the child. In 44 cases, or 77.2% of interviews, this accompanying adult was the child's mother. The participant's father accompanied eight interviews (14.0%), whereas in exceptional cases, the child's sister (twice), grandmother, cousin or guardian (once each) was the literal *compagnon de route*. To guarantee anonymity, each interview participant and accompanying adult was assigned a unique identifying code which is used for quote identification. This code consists of the child's place in the interview sequence by school, followed by the number of that school. The school in Newham was assigned the code S1, the school east of the Underground line in Brent received code S2, and the school west of that line was assigned code S3. For example, I7_S1 refers to the seventh interview carried out in the school in Newham.

III. Accelerometry and activity diary results

The accelerometers worn by participants for seven days following the interview enable the reconstruction of their objective patterns of physical activity during a normal school week in the period of October to February. These data are supported and contextualised by their self-reported activity levels recorded in the tick-box diaries they were asked to complete during the week of accelerometry.

These quantitative data set the scene for the qualitative exploration of children's regular physical activity levels, in search of context-specific drivers of, and barriers to, active commuting and out-of-school sports and exercise through go-along interviews. I explicitly avoid positivist analyses in this stage of the explanatory sequential mixed-methods research, especially as the sample of 57 schoolchildren does not allow for in-depth statistical analyses taking potential confounding and mediating factors into account. Therefore, the accelerometer data are presented broken down by school, children's individual characteristics, and the time of day and week. The trends that emerge from these displays are then discussed, without the aim of searching for statistical significance or confidence intervals.

For 53 out of 57 (93.0%) pupils included in the sample, the minimum inclusion requirements of six hours of accelerometer recordings for at least two weekdays and one weekend day were met. *Table 23* summarises these accelerometer data by school, focusing on MVPA, of which each child should collect a minimum 60 minutes every day in order to meet WHO activity guidelines.

On average, the included children gathered 54.6 minutes of MVPA per day, which is around ten percent below the WHO-recommended minimum. However, activity levels differed strongly by school. With an average of 63.8 minutes of daily physical activity of at least moderate intensity, the pupils attending the participating school in Newham did achieve the activity goal. In contrast, those in Brent only collected around 50 minutes of MVPA, falling well below the WHO standards. These figures might be impacted by the performance of interviews in Newham in the slightly warmer months of October, November and December, whereas those in Brent were carried out in the coldest winter months, January and February.

On the individual level, only six pupils met the activity standards every single day of the week for which recordings were available. This leaves about 90% of children falling short of healthy levels of daily physical activity. The image improves slightly when the total time spent engaging in MVPA was averaged out across the week, though, even then, only some 40% of participants attained the activity minima. Pupils with higher levels of overall physical activity also recorded longer bouts of MVPA, entailing additional health benefits.

Accelerometry Data by School					
School	**School Newham**	**Brent School 1**	**Brent School 2**	**Total**	**Percentage of total**
Number of valid (invalid) recordings	**19 (3)**	**18 (1)**	**16 (0)**	**53 (4)**	**93.0**
Minutes of daily MVPA – total	**63.8**	**48.0**	**52.3**	**54.6**	
Meets MVPA guidelines – strict criteria					
Yes	4	1	1	6	11.3
No	15	17	15	47	88.7
Meets MVPA guidelines – on average					
Yes	9	5	7	21	39.6
No	10	13	9	32	60.4
Minutes (%) of MVPA – per week day	**72.8**	**51.6**	**58.1**	**61.4**	
Pre-school	6.4 (9)	2.7 (5)	6.3 (11)	5.1	8.3
School	41.3 (57)	28.5(55)	32.5 (56)	34.4	56.0
Post-school	25.1 (34)	20.4 (40)	19.3 (33)	21.9	35.7
Minutes (%) of MVPA – per weekend day	**47.1**	**39.0**	**38.2**	**41.7**	
Morning (7am – 12 noon)	9.0 (19)	14.0 (36)	7.3 (19)	10.2	24.5
Afternoon (12 noon – 5pm)	21.6 (46)	17.1 (44)	18.0 (47)	19.0	45.5
Evening (5pm – 11pm)	16.5 (35)	7.9 (20)	12.9 (34)	12.5	30.0
Minutes (%) of MVPA on weekdays – active commuters (excl. mixed)	**64.1**	**59.1**	**56.6**	**59.6**	
Pre-school	5.3 (8)	1.2 (2)	8.2 (15)	5.2	8.7
School	39.3 (62)	33.5(56)	29.7 (52)	33.8	56.7
Post-school	19.5 (30)	24.4 (42)	18.7 (33)	20.6	34.6
Minutes (%) of MVPA on weekdays – passive commuters (excl. mixed)	**74.6**	**46.7**	**54.9**	**58.6**	
Pre-school	3.5 (5)	3.6 (8)	4.0 (7)	3.7	6.3
School	40.1 (54)	23.4 (50)	32.6 (59)	31.7	54.1
Post-school	31.0 (41)	19.7 (42)	18.3 (34)	23.2	39.6
Minutes Average MVPA Bout Duration – total	2.5	2.2	2.1	2.3	
Minutes Average MVPA Bout Duration – Weekdays	2.7	2.3	2.1	2.4	
Minutes Average MVPA Bout Duration – Weekends	2.0	2.2	2.0	2.1	

Table 23: Accelerometry data by school (MVPA: Moderate-to-Vigorous Physical Activity)

Stark differences also emerged in terms of the timing of this activity throughout the day and week. On weekdays, participating pupils averaged 61.4 minutes of MVPA, a figure which, again, was higher for children in Newham, with those in Brent missing activity targets. It is striking to note that well over half (56.0%) of children's MVPA was collected during school hours, a figure consistent across the schools. In the seven hours between the end of school and primary schoolchildren's bedtime (4pm-11pm in my accelerometer measurements), they only collected about a third of their daily required MVPA. This implies that the school is not only the primary education provider, but also, and increasingly, appears to be tasked with ensuring children adopt and adhere to healthy lifestyles. This observation was amplified by the accelerometer data collected during weekends, pointing to a drop in MVPA of over 30% for pupils of all three schools on Saturday and Sunday, to a daily average of 41.7 minutes. On days where primary schoolchildren had no school-related obligations, their time spent in sedentary activities thus peaked. Patterns of MVPA did not differ strongly throughout the day for children commuting actively or passively to school. Overall, active commuters spent one additional minute being moderately or vigorously active during weekdays. These children collected only a slightly higher share of their MVPA before school started (8.7% versus 6.3%), indicating that their additional physical activity while travelling to school largely failed to meet the MVPA intensity threshold. In turn, their passively commuting peers collected a larger share of their daily activity after the end of school (39.6% versus 34.6%). Participants attending the school in Newham did not follow this overall trend, as pupils travelling to school using passive means of transport collected some ten minutes of additional MVPA in comparison to actively commuting children.

The accelerometer data collected in the week following the go-alongs also showed strong variations between participants based on their personal characteristics (*table 24*).

Accelerometry Data by Individual Characteristics			
Personal Characteristic	Minutes of daily MVPA - Weekdays	Minutes of daily MVPA - Weekends	**Minutes of daily MVPA - Total**
Sex			
Boys	72.8	46.6	**64.3**
Girls	49.1	35.9	**44.6**
Age			
7-9	59.2	41.4	**52.6**
10-11	65.4	41.3	**58.2**
Ethnicity			
Black	71.0	44.0	**61.4**
South Asian	51.7	40.8	**48.5**
White	59.5	33.5	**50.5**
Mixed/Other	54.6	46.2	**52.4**
Mode of Commuting to school (Based on diary)			
Active	59.6	51.4	**56.3**
Mixed	75.1	52.6	**69.7**
Passive	58.6	30.6	**48.8**

Table 24: Accelerometry data by individual characteristics (MVPA: Moderate-to-Vigorous Physical Activity)

Boys met daily MVPA minima, engaging in 64.3 minutes of moderate-to-vigorously intense sports and exercise on average. This was mainly due to their higher levels of physical activity on schooldays, as they tend to dominate school playgrounds with their activity during breaktimes. Averaging 44.6 minutes of MVPA per day, girls fell well short of meeting WHO activity guidelines, collecting only just over half an hour of activity on Saturday and Sunday. Children aged ten and eleven were found to be more active than their younger peers, gathering some ten percent more minutes of MVPA on a daily basis than children between the ages of seven and nine. Together, these data substantiate the image of boys and older children attaining higher physical activity levels, in part due to their greater freedom to be independently active. Breaking down the accelerometry recordings by ethnicity, participants of black African ancestry were the only group who accumulated an hour of daily MVPA. Children of South Asian, White, mixed or other ethnicities were far less active, collecting only around 50 minutes of strenuous activity every day. Finally, passively commuting pupils were found to be less active throughout the week compared to their actively commuting peers or those who used both active and passive modes of transport to school. Passive commuters were particularly less active on the weekend, suggesting active and mixed commuters were drawn to forms of out-of-school physical activity beyond the walk or cycle to school. The 'mixed' group was most active overall, at an average of nearly 70 minutes of daily MVPA. This figure should, however, be interpreted with caution, as they represent a relatively small share of the total sample (14.0%, see *table 25* below). These findings highlight that regular use of active modes of commuting entailed overall healthier activity habits throughout the week for the studied sample of children in Newham and Brent.

These objective, quantitative accelerometer data provide an insight into when participants were active, for how long, and with what intensity. They do not, however, reveal the type of physical activity children engaged in. Therefore, participants' responses recorded in the activity diaries are a helpful aid to contextualise the accelerometry data, as presented in *table 25*. Moreover, these self-reported data can later be matched with children's narratives on commuting and extracurricular sports engagement constructed during the go-alongs.

Activity Diary Data by School					
School	**School Newham**	**Brent School 1**	**Brent School 2**	**Total**	**Percentage of total**
Mode of Commuting to school	**22**	**19**	**16**	**57**	
Active	8	6	8	22	38.6
Mixed	5	2	1	8	14.0
Passive	9	11	7	27	47.4
Mode of Commuting from school					
Active	6	6	8	20	35.0
Mixed	7	1	3	11	19.4
Passive	9	12	5	26	45.6
Extracurricular sports engagement (frequency per week)					
Never	2	1	1	4	7.0
1-3	10	9	4	23	40.4
4-6	7	7	8	22	38.6
Daily	3	2	3	8	14.0
Extracurricular outdoor play (frequency per week)					
Never	11	9	7	27	47.4
1-3	10	10	6	26	45.6
4-6	1	0	3	4	7.0
Daily	0	0	0	0	0.0
Extracurricular screen-based activities (frequency per week)					
Never	1	0	4	5	8.8
1-3	2	3	3	8	14.0
4-6	8	11	7	26	45.6
Daily	11	5	2	18	31.6

Table 25: Activity diary data by school

38.6% of included pupils consistently commuted actively to school in the week following the interview, a figure slightly below the share of go-along interviews that was carried out while walking to school. 35% of children actively travelled back home after school, with an increase in mixed modes of transports being used for the after-school commute. Just under half of children included in the study commuted passively on the way to and from school.

The activity diaries point to a lack of engagement in moderate-to-vigorously intense activities outside of school hours, which underpins the low extracurricular accelerometer readings. Only 14.0% of children reported daily out-of-school sports engagements, and no single participant indicated engagement in free, outdoor play on a daily basis. Concerningly, 93.0% of included pupils mentioned using the public space for unstructured play up to only three times per week, with nearly half indicating that they had not once played outside in the week following the go-along. Looking at screen-based activities, it is clear children spent their time engaging in sedentary activities. A third of participants surfed the web, watched television or used a game console every single day of the week, with three-quarters doing so at least every other day. Only five boys and girls taking part in the study, amounting to less than ten percent, indicated a complete lack of engagement with this type of activity.

IV. Subjective lived experiences – results from the abductive thematic analysis

The accelerometer and activity diary data provide the quantitative contextual background to the qualitative exploration of children's lifeworlds. They show that the go-along interviews were set in urban environments where nearly 90% of included children fail to meet activity requirements, and girls, younger children, non-black participants, and passive commuters were confronted with particularly high levels of inactivity. Out-of-school physical activity was especially lacking, with schools having become the primary provider of sports, play and exercise. These findings underline the urgent need to identify the local, context-specific drivers of, and barriers to, extracurricular physical activity, in order to ensure children are able and stimulated to adopt healthy lifestyles outside of school.

The go-along interviews were designed to collect this information. Kilometre after kilometre, the primary schoolchildren painted a detailed, personal and context-specific portrait of their very own lived experiences in their very own bit of London. The voices of these children therefore deserve to take centre-stage. The abductive thematic analysis allowed me to unravel their narratives and assign subjective perceptions and opinions to the relevant constituent vertex of the ecological models developed in the conceptual framework (*figures 1* and *2* in chapter 2). Hence, this paragraph follows the structure of the ecological model, and discusses children's experiences in relation to the habitat, population and behavioural vertices sequentially.

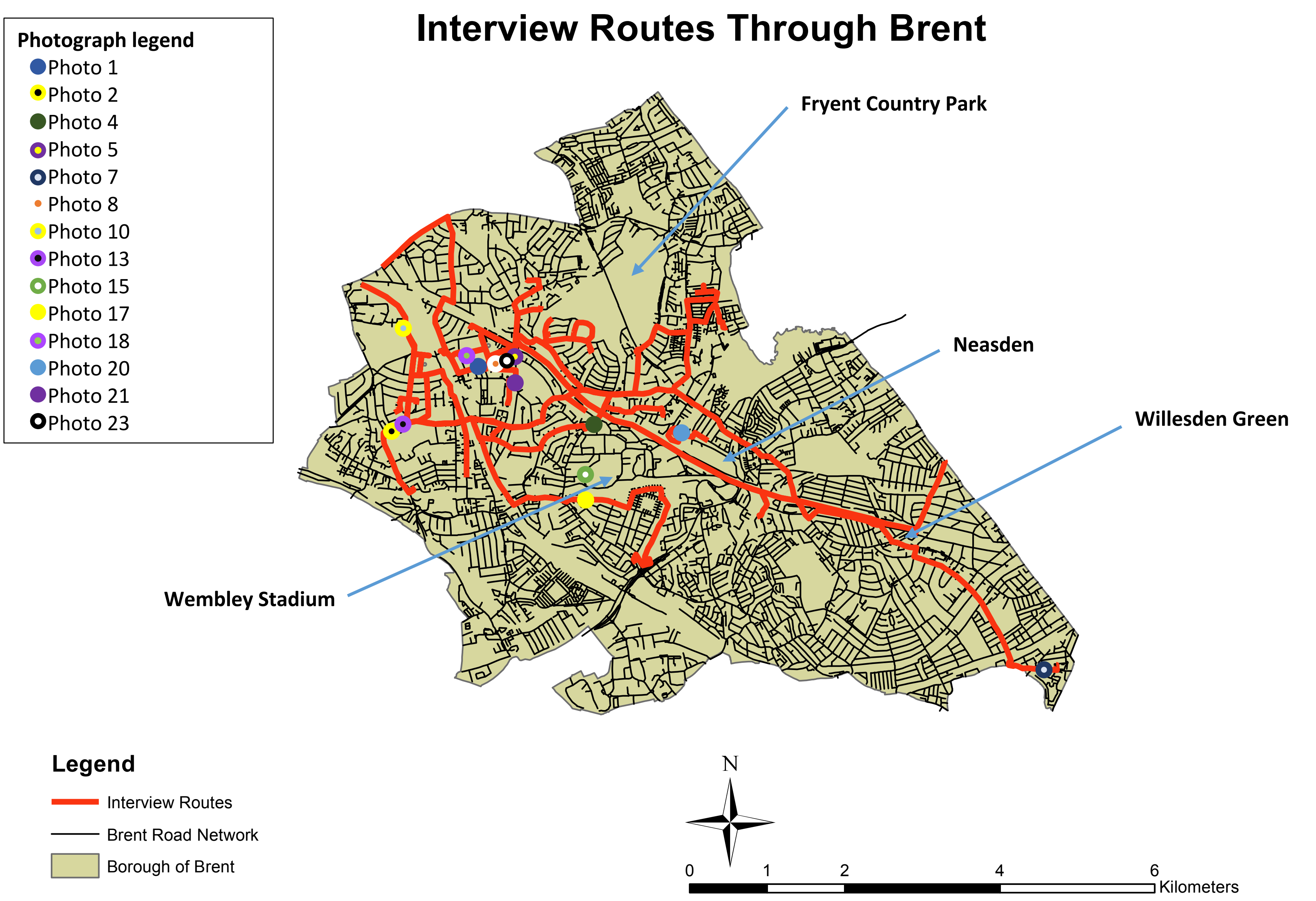
The quantitative stage pointed to the pivotal role of physical activity, and in particular commuting, in mediating the relation between the built environment of children and their body composition. Therefore, the analysis of my results centres around the energy expenditure-inciting or -discouraging characteristics of the outdoor public space as perceived by participants. These are discussed separately for pupils' active or passive school travel on the one hand, and extracurricular recreation and exercise on the other. For each activity component and model vertex, first, the results that address the deductively established themes are discussed, followed by the presentation of new themes emerging from the interviews that were not accounted for in the spatial epidemiological study.

Keeping the child's own voice at the heart of my study, these observations are extensively supported by their verbatim quotes and illustrated with photographs. To connect what participants say with where they say it (Jones et al. 2008), these striking quotes and associated images are then situated on their exact location along the interview routes across Brent and Newham, shown in *maps 15* and *16*. Each quoted photograph is located on the maps as a coloured dot with its associated identification number in the legend, using the GPS coordinates recorded during the go-alongs. These provide a spatial insight into the lived experiences of the interviewed children through qualitative GIS.

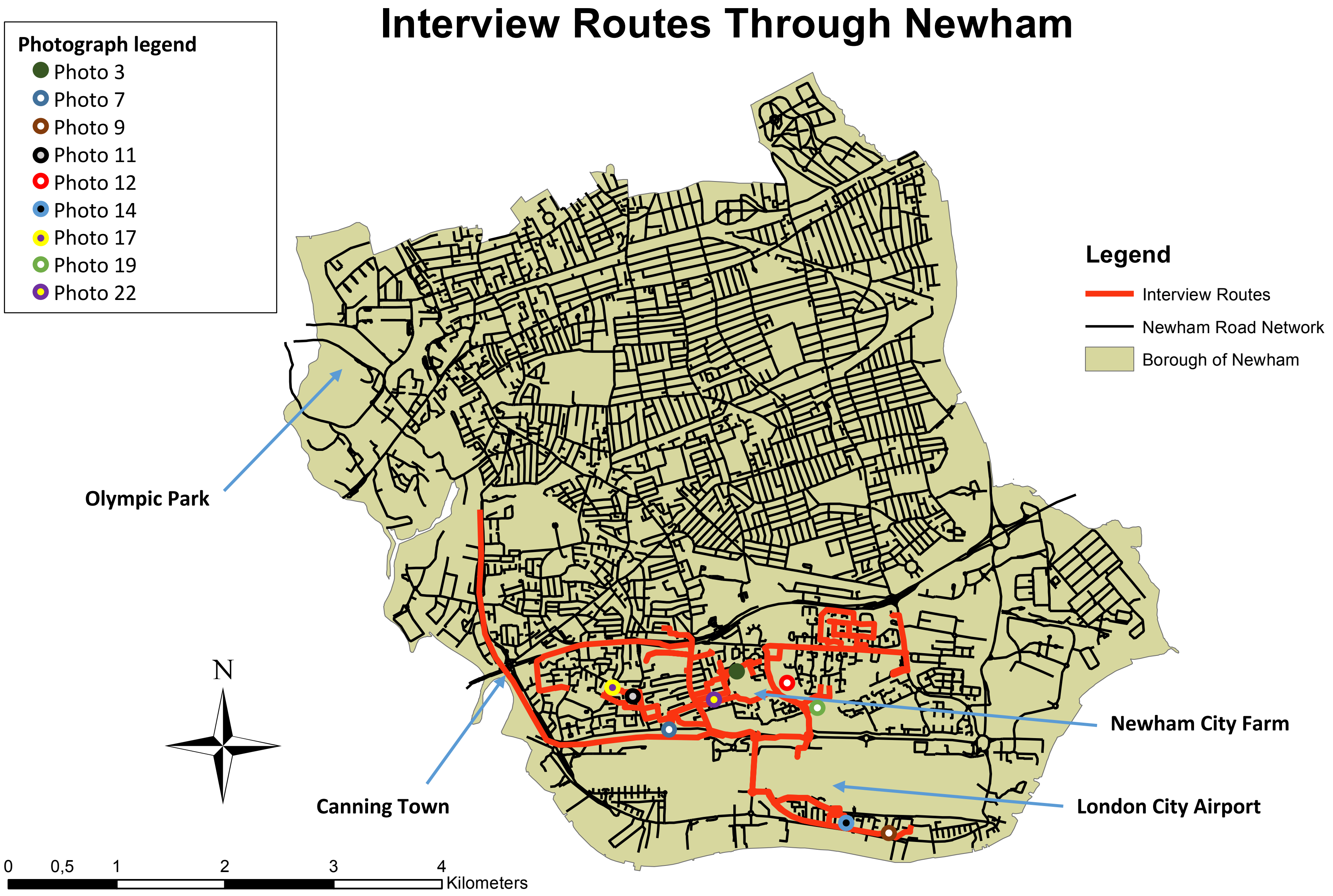
a. Activity component 1 of 2: The human ecology of children's school travel

The interviewed children frequently and spontaneously touched upon the set of six environmental characteristics that formed the pinnacle of the spatial epidemiological study in the first research stage in relation to their daily school commute. These characteristics, constituting the deductively established codes in my thematic analysis, are discussed here in relation to their relevant ecological model vertex, supplemented by new insights gained from the interviews.

Map 15: Interview routes through Brent



Map 16: Interview routes through Newham



i. The Habitat Vertex

<u>The Built Environment</u>

Proximity emerges as a key factor determining the choice of passive or active modes of commuting. GPS data demonstrate that destinations within one kilometre were primarily reached on foot, by bike or scooter, whereas longer commutes were bridged by car or public transport. Very few children opted for passive modes of commuting below one kilometre. However, choosing for active forms of transportation beyond this distance was equally rare, amounting to a strong argument for the provision of a wide diversity of facilities close to residential areas and within children's walking and cycling perimeters. However, in neither Borough are schools always this close. One mother mentioned she would have preferred *"a school around the corner"* (mother I9_S3), allowing her family to actively commute, but her son ended up being sent to a school further afield due to long waiting lists. Such school allocation policies result in an overreliance on avoidable private car use. Physical distance was often closely tied to the perception of time. Walking to school for 25 minutes was defined as *"quite far"* (I7_S1). At the same time, children often perceived travel by car and public transport to be quicker than walking, though this was rarely the case, especially for shorter commutes. Whilst long distances thus incite passive commuting, a modal shift from car-based to public transport could be achieved by catering to the need for a well-connected and dense bus, rail and underground network. If not present, children and parents will continue to be forced to make use of private motorised vehicles for longer commutes: *"It is a bad thing that the bus stop is fifteen minutes away. [...] I wish it was closer."* (I16_S2).

The positive proximity effect tended, however, to be overshadowed by a materialised fear of motorised traffic, and cars in particular, to which participants made ample reference. Both active and passive commuters expressed their concern, not only about the volumes of motorised vehicles on the road, but also the behaviour of motorists while travelling to school. *"On some occasions there is so many cars coming from so many directions, it's a bit scary"* (I3_S2). As interviewer, I was frequently exposed to this danger in real-life while going along with children. On one occasion, a driver ignored a red traffic light, managed to stop with screeching tyres, and subsequently honked aggressively. The interviewed child in question simply observed: *"Cars are driving really fast. There are skid marks on our road"* (I14_S3).

Whilst parents often supported their child's concerns about traffic safety, they didn't always act as responsible role models themselves. When entering the street where school S3 in Brent is located, the same child noted that *"you know on [school street], it's a one-way drive but people don't respect it".* Even those who are ultimately responsible for the enforcement of safe traffic conditions, the Police, contributed to active commuters' fears when crossing the public space. The mother of a child usually biking to school did not allow her son to cycle on their home street, as *"there's a Police station nearby, so they go really fast, so they made the humps [to slow down traffic] really far apart. [...] They made the road twenty miles per hour, and nobody observes it. Sometimes there are cars dashing, like, forty miles per hour"* (I6_S3).

The concerns about traffic risk did not, however, span the entire route to and from school. Participants pointed out very specific hotspots of traffic-related risk. These were mainly situated in close proximity to school and arose within well-defined timeframes during the hustle and bustle around school start and end times. Parents driving their children to school queued to drop off their children, causing traffic jams while rushing, thereby endangering those who walked, cycled or scootered to school. *"Sometimes we can't find any space to carry on on the footpath [due to parked cars], so we have to continue on the road"* (I1_S2). The high speeds some cars developed after having dropped of their children, in combination with cars parked on either side of the road, then made crossing the street a highly dangerous undertaking, especially for young children with reduced capacity to estimate velocity. However, instead of providing a zebra crossing close the school, Brent Borough Council opted for signs encouraging cars to slow down around school S2 (*photo 1*).

Photo 1: Cars speeding through a road leading to school S2, without zebra crossing

Where pedestrian and cycling infrastructure was present, this was often in poor condition. Cracks in the paving slabs and potholes that remain unfilled led to the impression that *"going by bike or scooter is even more of a hazardous... the area is built for cars streets are absolutely anti-cycling"* (I6_S3). The few children who still cycled to school, despite the absence of cycling infrastructure and the unsuitability of the pavement for bikes, indicated their struggles in doing so. Numerous children knew precisely which locations posed the highest risk, and recounted personal, embodied and materialised experiences with injury and danger as we walked along the routes to and from school. A girl pointed to a crack in the pavement, saying *"what I remember, when I was in Reception, somebody broke their leg while they were biking on this road"* (I3_S2). Some loose paving slabs had simply been highlighted using white paint, though remained untouched for years (*photo 2*). Another child explained their choice to walk to school, rather than cycle or scoot, was as a result of the pavement condition, because *"if you want to scooter or drive a bike, you normally fall down"* (I4_S2).

Photo 2: Loose tiles are highlighted, but not repaired

This feeling of a lack of safety expressed by children during the go-alongs was closely intertwined with their perception of the walkability of the neighbourhoods they crossed *en route* to and from school. However, the components of Stockton's Walkability Index (2016) – residential density, street connectivity and land use mix – were not directly discussed by participants. Minors experience their surroundings differently to adults, resulting in a different set of built environmental characteristics that constitute subjectively perceived walkability. Two key elements stood out from the narratives collected during the go-along interviews: the presence of zebra crossings, and the presence of fellow commuters on the streets.

The provision of the zebra crossings can be interpreted as enhancing street connectivity, though their importance surpasses that of being a simple, commonly used proxy for intersection density frequently employed in prior walkability studies. The notable absence of safe places to cross on crucial places during the school commute caused significant anxiety among children. Even where zebra crossings are provided, these rarely alleviate the insecurities of participants, as drivers frequently refuse to give way to crossing commuters: *"When we get to the crossing, cars don't stop and let us cross. It happened right now: someone was waiting to cross and the motorbike just passed and didn't stop"* (I16_S1). Traffic lights tended to reduce this risk, though the go-along interviews showed that these did not always function either. *"There's lots of cars coming and the lights don't work"* (I16_S2). Confronted with this hazard and consequential reduced walkability of the road environment, children develop risk-reducing strategies. Children give way, or search for alternative, safer spots to cross the road, something they explain during the interviews: *"I am careful, I always let the cars go first"* (I8_S1), or *"The vans are parked near the yellow lines and I can't see too well, so I have to walk further to cross the road. There is like a blind spot next to the yellow lines."* (I1_S2). For accompanying adults, these unsafe conditions at critical points along the commuting route were decisive factors in the decision to limit children's in(ter)dependent mobilities. One mother did not allow her son to walk to school by himself, because *"us getting to school, we have to cross [a main road], and that's a big, big road. I mean, for the safety of the children"* (mother I11_S2).

The second main walkability-related variable participants referred to concerns the density of people in the public space, related to residential density in the adult-centred walkability indices. Children expressed a clear preference for walking in environments where the presence of other people provided a sense of security. Routes were adapted to limit the time spent out of view. A girl preferred avoiding a certain alleyway which could serve as a shortcut because *"It's more safe than… because they can see you. I like when people look [...] if there was something, people could see and do something"* (I5_S1, *photo 3*). Particularly in Newham, where a dense network of narrow, rather desolate alleyways provides higher street connectivity, children's sense of risk prevents them from making optimal use of the quickest routes.

Photo 3: Children feel unsafe in narrow, empty alleyways in Newham

Perhaps the strongest determinant of the neighbourhood's walkability was, however, not a constituent part of conventional walkability studies. As hinted at above in relation to traffic safety, the condition and maintenance of pavements was crucial to incite children to opt for walking, cycling or scootering as the main mode of transport to school. As road-sharing is made near-impossible on London roads due to the fierce competition with and risk posed by motorised transport, children are often constrained to using pavements for their active commuting. This resulted in a busy concoction of pedestrians, cyclists, children on scooters, dogs and prams during the go-alongs, especially in the streets closest to the included schools. This deterred children from engaging in active transport: *"All people are walking and you might hit someone"* (I11_S2). Cycling, especially, suffered from a lack of adequate provisions in both Brent and Newham. Pavements were, however, lived and lively material entities, where people, animals, plants and dirt – especially dog faeces – increased or decreased the walkability of the public space to varying extents. In Brent, this problem was amplified due to the presence of Wembley Stadium and associated event spaces, resulting frequently in excessively high densities of people, inhibiting children's use of the outdoor environment for transport. *"It's a struggle for us to get past. [...] People hurt themselves when trying to pass the crowd"* (I5_S3, *photo 4*). The presence of others thus not only provides a much-needed feeling of safety for children but, above a certain threshold, also rules them out of the road environment.

Photo 4: High volumes of people around Wembley Stadium rule children out of the public space

Other children struggled more with the poor state of the pavements. In Brent, this was primarily related to the tiled pavements which were full of cracks and uneven paving slabs: *"I've fallen ten times"* (I10_S2) and, in relation to scootering, *"Most likely you fall over when your wheel gets stuck in the cracks"* (I9_S2). In Newham, the lack of cleanliness was the main source of irritation, with pavements being littered with dog faeces – *"we always have to be really careful and watch our step, we have to walk around it"* (I1_S1).

In both Boroughs, the foodscape also emerged a topic of commuting-related conversation, though only after probing using the open-ended, deductively developed topic list. Asked about the food environment along their commuting routes, actively commuting children highlighted that they and their accompanying adults regularly stopped by convenience stores or fast-food outlets on the way home from school. The purchased foodstuffs were mainly unhealthy, energy-dense products, such as sweets, serving as a treat after a long school day, or a quick and easy fried dinner. The chicken and chips shops close to the schools in both Brent and Newham were particularly popular. An eight-year-old boy thought it was inappropriate to have such fast-food shops in the area around school *"because some teenagers maybe just hang around in the shop and then buy some stuff without their parents knowing. I know a few friends of mine that do that."* (I4_S3, *photo 5*). Only on one occasion did a child mention purchasing healthy products together with his grandmother, albeit this was not always his preferred choice: *"I like to buy cherries and other fruits and sometimes – if I'm good – a chocolate"* (I14_S1).

Photo 5: Chicken and chip shop visited by schoolchildren in Brent

None of the children referred to the foodscape as a determining factor for the choice of an active mode of commuting. Nonetheless, their exposure to food outlets along the roadside implies a perhaps subconscious encouragement of the consumption of unhealthy food items. On the other hand, several parents who picked up their children from school by car explained their choice of private motorised transport was motivated by the need to go food shopping elsewhere in the neighbourhood after school. The centralisation of supermarkets and other shops in large retail parks outside residential areas thus seemed to entail an increase in passive commuting, especially in Newham.

The final predetermined component of the built environment belonging to the habitat vertex, pollution, was a hot topic during the go-along interviews. Children were outspokenly critical of air pollution, often following classes on this topic at school. *"Look at that one!"* exclaimed a child when a car speeded past with visible fumes from the vehicle's exhaust pipe (I18_S2). The interviewed pupils were aware of the detrimental health impacts of air pollution, both in general terms – *"It's really smoky, and it's not good for you if the smoke is coming from the cars"* (I1_S2) – and in relation to specific health conditions – *"I know a few people with asthma, and they are telling me it's hard to breathe, so they try to run there [along the busy road] as fast as they can"* (I14_S3).

However, moving beyond the air pollution analysed in the quantitative stage, another form of pollution stood out that was not included in the spatial epidemiological study: noise pollution. *"People do silly things. Like, last week there was this man, and he was blocking the road, and everybody, like, they beat their horns and it was so noisy and stressed… Car drivers shouting at teachers and blowing the horn"* (I16_S3), or *"Some people scare children, because they go fast and then they stop, they stop really loud"* (I16_S1). This excessive noise makes children feel uneasy. This is particularly the case around London City Airport, in close proximity to the school in Newham, where the new Elizabeth London Underground line (Crossrail) is being constructed (*photo 6*). The sound of airplanes taking off and the relentless industrial noise stemming from the building works are severely disruptive of children's social interactions and circadian rhythm. *"There is a lot of noise from the streets. I can't sleep because of the noise"* (I11_S1). During the day, *"The neighbourhood is noisy, always planes [...] It bothers when I am outside"* (I7_S1), and *"My brother stops talking [when a plane flies over], and then he forgets what he was saying"* (I1_S1). Moreover, in-school activity is also disturbed by the airplanes: *"The airplanes are annoying, because in school they keep interrupting the lesson"* (I15_S12).

Photo 6: The construction of Crossrail is highly disturbing for children throughout the day and night

Beyond the deductive themes, new drivers of, and barriers to, children's active commuting were also observed. Well-lit streets increased children's likelihood of opting for walking or cycling to school. Pupils avoided dark alleyways. The setting of my study in autumn and winter months highlighted the importance of providing year-round street lighting, making children feel at ease, and relieving their darkness-induced anxiety. Similarly, historic aspects or quirks about otherwise ordinary routes to school fascinated children. These stimulated their imagination, and, for those who used active modes of transport and experienced direct contact with their surroundings, contributed to their enjoyment of the commute: *"I like this street, because, a long time ago, it was a path from the Viking Kingdom"* (I2_S2).

<u>The Natural Environment</u>

The second core element of the habitat vertex in the ecological model is the natural environment. Within this overarching component, the importance of weather, climate and seasonality stands out from the go-alongs. The limited daylight and early dusk, which often set in as the interviews were taking place on the way home from school during autumn and winter months, contributed to children enjoying their commute less, at times even making them feel distinctly unheimlich. This was felt particularly strongly by children who were acquainted with other geographic climates, either having lived elsewhere prior to moving to the UK, or having spent considerable time visiting relatives abroad: *"The darkness in England, […] I always have a feeling that a storm is going to start"* (I2_S1).

Precipitation in particular, whether rain or snow, often resulted in pupils expressing a preference for passive modes of commuting. On the other hand, children described sunny spring and summer days as ideal stimuli for walking or cycling to school. This resulted in a sharp distinction between higher levels of active commuting during the warmer half of the year, and more motorised transport during autumn and winter: *"So, in winter, we don't take our bikes much because it's cold so mostly we go by car"* (I9_S2). These preferences were shared by the accompanying adults: *"We don't actually walk that much in the winter, because like, dad says it's cold and he normally drops us off so we don't walk"* (I16_S3). This argument was often substantiated by a fear of illness and injury due to the poor outdoor climatic conditions, and the additional danger posed by

Photo 7: Weather and climate impact commuting preferences through perceived risk

slippery pavements and darkness (*photo 7*). Even in autumn, leaves on the pavement reduced children's likelihood of opting for active modes of transport, as they result in conditions that are *"slippery and dangerous to cycle"* (I9_S3).

Irrespective of the weather, children frequently expressed their enjoyment of and amazement by the world that surrounds them, stimulating their fantasy and sense of adventure. This was particularly the case for actively commuting children, who experienced direct contact with their natural environment. Children were attracted towards walking to school by both plants and animals, which they appreciated at specific points along the route. These included larger features of greenspace such as parks, ponds or, in Newham, the City Farm, as well as microlevel features such as one specific flower bed where a participant counted the number of plants: *"I'll show you, it is extremely pretty. There's loads of colours, actually flowers. You won't believe. We took this metre stick outside. I got shocked as to how many flowers I found in just one square metre. There were one hundred, one hundred and fifty! And the bushes, they are so green. And green is my favourite colour. And it just makes me happy"* (I10_S2). For several children, the natural environment was a key reason for their preference to walk or cycle to school: *"I prefer walking over taking the bus, the walk is quiet and the farm is on the way"* (I8_S1).

However, not all elements of the natural world were unanimously perceived as positive, especially animals. Some children got excited at the sight of a dog or fox, whereas others found those animals scary. This resulted in one child feeling uneasy at the thought of having foxes around in the neighbourhood – *"once on the way to school I saw a dead fox! [...] It probably came out at night. It was very scary. It freaked me out."* (I3_S3). However, another mentions them among her list of favourite things about her neighbourhood: *"sometimes we get to see the animals, there's some horses, and ducks, and foxes"* (I13_S1). Similarly, dogs can both enhance and reduce the attractiveness of walking to school: *"Sometimes, people with dogs, they take their leads off, and then the dog could run around free, and some people don't like dogs running around free. I mean, I sometimes like dogs, but some dogs are more vicious dogs than others"* (I21_S1). Poorly maintained greenspace also detracted from a pleasant commute. High, unkept hedges blocking children's view of the road environment were particularly concerning. *"There's a hedge alongside the way to go to the school. And so* *you can't ride a bike or else you'll fall",* one child residing in a residential environment close to school S2 mentions about a hedge on the corner of a road she needs to cross (I4_S2, *photo 8*). This underscores the need to adopt a child perspective, not only in a conceptual sense, but also in a physical sense, as often these same features do not present obstacles for taller adults and would therefore go unnoticed when observing neighbourhoods through adult eyes.

Photo 8: Unkept hedges block children's view, thereby posing danger

Alongside the physical built environment, the natural environment thus plays a key role in determining the commuting mode of children. However, other physical geographical elements, such as topography, which could have been expected to have been brought up by participants, were rarely mentioned by the children as decisive in their commuting choices, with one notable exception. A girl living on a steep hill northeast of Wembley mentions she likes going by car because *"It kind of warms me before I get out of the car"* (I17_S2), after which her sister adds *"And you don't want to walk down".*

<u>The Social Environment</u>

The final component of the habitat vertex, the social environment, includes structural family and community sociocultural, economic and lifestyle characteristics. Within this broad range of factors that could potentially influence children's commuting decisions, family car ownership increased the frequency of passive commuting, an effect which was amplified when both parents had access to private motorised transport in dual earner families. In the rare cases where families had no access to a car, or where one or both parents did not have a driving license, children perceived this as a positive stimulus for active commuting or travelling to school by public transport: *"My dad doesn't like cars, and he thinks we should get used to public transport and we need to get used to different routes and stuff"* (I4_S2).

This quote also emphasises the importance of parental role modelling, and the partiality of children's voicings, whose interdependent judgement of commuting modes is impacted by the opinion of their parents, siblings and peers. Nonetheless, even parents' own judgements were not wholly independent. Accompanying adults regularly highlighted that they experienced a significant societal pressure that deterred them from opting for active modes of transport to school, and especially for children to be independently mobile. School policies preventing children from walking, cycling or scootering to school on their own or with siblings or peers until Year 5 created an atmosphere of fear. Parents frequently described the independent mobility of primary schoolchildren as 'irresponsible', even when they were about to reach Year 6: *"It would make me very nervous when he walks on his own. [...] I would have to think twice."* (mother I3_S2). This results in a situation where active commuting becomes a last-ditch travel option in case all else fails: *"We only walk to school when the bridge is closed, because then the bus can't go"* (I7_S1).

The refusal to allow children to travel to school by themselves entails a need to fit the school commute into a family's daily routine. This further reduces the likelihood children will gather much-needed physical activity, as walking or cycling doesn't match parental time constraints and working schedules. Several accompanying adults expressed a desire to actively commute, but for a whole host of reasons explained why they couldn't do so in practice. This was often frustrating for children, who much preferred active commuting because of the possibility of sharing stories with their parents and peers and directly engaging with their outdoor environments: *"My most favourite thing when we are walking is that sometimes we go with our friends"* (I9_S2). Participants often made use of the opportunity provided by the interview to question their accompanying adult on this issue: *"But why do we have to take the car? Because we don't live that far?",* forcing the parent into the defence: *"It's only because after school they got activities. [...] I go home quick for cooking and Thursday I work till six o'clock"* (I19_S2 and mother).

If possible, parents reallocated the drop-off and pick-up duty to older siblings, who were therefore key to both active and in(ter)dependent mobility. Nonetheless, this was not always appreciated by the latter: *"My little sister can stop in the middle of the road for whatever reason. [She] can't walk all the way."* (sister I16_S3). There was, however, a minority of parents who explicitly indicated a desire to walk to school for health reasons, suggesting there are potential pathways to incite adults to choose active modes of commuting. One mother, who couldn't keep up with her daughter during the interview, was keen to walk to school *"because mommy is losing weight. She wants skinny legs. She tells me I have skinny legs. She wanted to get skinnier"* (I8_S1).

Aside from these family-level considerations, the sixth characteristic included in the spatial epidemiological study – crime and remnants of antisocial behaviour – stood out as a driver of passive commuting, especially in Newham. While those driving to school described criminal acts in fairly abstract terms based on hearsay, during walk-alongs to and from school or across the neighbourhood on the weekend, the interviewer-interviewee pair were overtly exposed to signs of criminal behaviour that inspired anxiety among pupils and accompanying adults. The go-alongs brought us past an aggressive, intoxicated individual; burnt motorcycles and bins; and, perhaps most grippingly, the name of a young victim of the knife crime and youth violence epidemic in London tagged on the wall, with whom the interviewed child was personally acquainted, being a good friend of the girl's brother (*photo 9*). These experiences left a deep impression on the children, and pushed them towards avoiding the outdoor public space as much as possible, including when travelling to school. A longer excerpt from the interview with the shooting victim's friend powerfully illustrates this:

I19_S1: "There was a gunshot in my area really close to the park, so near my house – remember I said I had to go through the park? – so it happened in that park. But, so, then I had… the boy walked into an alleyway, and then he stopped because the man stopped him and shot him. And then the ambulance came and then they had to use the [mimes defibrillator]…

Interviewer: "Ah, they had to shock him."

I19_S1: "Yeah, but he didn't wake up, so he died. And there's spray paint, his name is [K], and there's spray paint of [K] on the wall. So every time you pass you see where he died. And there was some flowers and… and then I got scared. And then there was a stabbing, near the shops. Near, erm…"

Interviewer: "And when did this happen?"

Photo 9: The alleyway where K. was murdered, and which I19_S1 has to cross every day on the way to school.

Mother I19_S1: "The stabbing was just in the corner shops near the house."

I19_S1: "But I was scared because my brother wanted to go to the shops. And he's 17, but then he was 16, to go to the shops. But then, a boy got stabbed in the spine. Also, a friend's brother, he got stabbed in the spine, but they still survived. And then there was another one…"

Mother I19_S1: "The day [K] died, the other boy got shot in the back and that one survived."

Interviewer: "Did you know [K]?"

I19: "It was my brother's friend. I knew him. And he was an only child, so then the mother was very sad."

These encounters with (remnants of) violence and crime during the commute to school are an important reminder that 'stranger danger' or perceived personal safety risks are not always an issue of imagined, irrational fear, but the reality of many London residents, and especially the youngest ones, when negotiating their outdoor environments. While roads might thus be objectively walkable, the atmosphere created by a sense of danger, amplified by *"creepy, scary graffiti in alleyways"* (I13_S3) and bad smells (*"Our area smells and it doesn't smell nice when we go to school"*, I22_S1) in both Boroughs, resulted in a tremendous loss of attractiveness of commuting routes.

ii. The Population Vertex

Included as confounders in the quantitative study, several elements of the population vertex emerged as mediators of the relation between the built environment and children's transport to school. While ethnicity did not appear to be a key driver of commuting decisions for the selected multi-ethnic sample of pupils, their age was clearly linked to their likelihood of in(ter)dependent active travel to school. As school policies only allow independent mobility from Year 5, parents indicated they trialled children's capacity to commute by themselves – either on foot for shorter distances, and public transport for longer routes – in the final two years of primary school. This was mainly done in preparation for secondary school, where there was a higher expectation that children travel to school autonomously. Nonetheless, these decisions were highly gendered, as female pupils were granted less freedom to actively travel on their own: *"I don't allow her to walk by herself. She's a girl."* (mother I3_S1). As indicated in the methodological chapter and in this chapter's introduction, the explicit inclusion or exclusion of children based on their body shape was not advisable in this qualitative research stage. Nonetheless, the maximum variation sampling strategy resulted in children of all body types being included. Children labelled as being overweight by their accompanying parent – for instance through the use of terms as 'a bit heavy' – described their preference for passive commutes because of the limited physical exercise required: *"I like driving to school. You just can relax, you don't have to take big steps around the area."* (I9_S1), and: *"I prefer to take the bus because my legs don't get tired all the time"* (I12_S1).

Two additional population-related facets of the human ecology of children's physical activity arose from the interviews. First, and linked to the observations on body shape, children referred to their physical condition or motor skills as a limiting factor in the choice to actively commute. Passive commuting was preferred by participants who shared that they felt unable to walk or cycle long distances. The symptoms of a lack of physical fitness included tiredness, shortness of breath, muscle ache and headaches, and were more frequently mentioned by children with fuller body shapes. Parents then tended to support – or even strengthen – these children in their desire not to engage in active commuting: *"my mum told me not to go by walk anymore ever, because [...] I had a really big headache"* (I14_S2). Secondly, there were striking differences in spatial awareness between active and passive commuters. Children who regularly walked or cycled to school were visibly more conscious of and familiar with their surroundings, and the risks and joys they entailed. They also demonstrated the capacity to optimise their commuting routes: *"We go here, it's a fast way"* (I16_S2). Children who rarely travelled to school using active modes of transport were less certain about the route to follow during the neighbourhood tours on the weekend. These participants asked accompanying adult for directions or confirmation, sometimes explicitly stating they preferred the presence of an adult as they feared getting lost otherwise. Children using a car or public transport to reach school were also less able to point out concrete points along the route that were of interest, that posed danger, or that they perceived as pleasant.

iii. The Behaviour Vertex

Social Organisation

School policies targeting child activity strongly impacted commuting decisions. Most influential was the rule preventing children from independent school travel until Year 5. Due to time constraints, this restricted the travel options for many families, posing a barrier to children's advancement of autonomy and cognitive skills gained through active and independent travel, crucial to their personal development. On the other hand, bike days and regular 'bike doctor' visits to schools seemed to stimulate the choice to cycle. Nonetheless, while children and parents were supportive of these initiatives, these were unable to eliminate the structural concerns commuters had about the built, natural and social environment. *"The school tries to stimulate active transport, like they do bike training. But I always want go on a bike with him, but there's his safety. I mean, we can't go all on the pavement together, it defeats the whole point anyways."* (mother I11_S2). Next, school admission policies also directly affected the active-passive commuting ratio, as children who were not accepted at their local schools needed to travel further, thereby raising their odds of using private or public motorised transport. Finally, confronted with high levels of knife crime, schools organised information and awareness-raising sessions on this topic. For children, however, these sessions instilled a sense of increased fear and discomfort about the outdoor public space they navigated. On the contrary, sessions on air pollution resulted in a well-informed student body, critical of excessive levels of vehicle exhaust and their health impacts, especially around the school gate.

The Borough Council also has a responsibility to stimulate active transport. The two schools in Brent, for instance, were keen proponents of a 'Park & Stride' policy, whereby free or cheap parking within walking distance from schools is provided for parents around school start and end times (*photo 10*). Parents can then make use of this facility to drop off or pick up their children, making the direct school environment safer and healthier for active commuters, while also stimulating physical activity among children who otherwise would have been dropped off directly at the school gate. At the same time, this would allow traffic restrictions to be implemented in the school streets. In the schools in Brent, however, only a voluntary Park & Stride policy was in place, with minimal uptake among parents. Traffic

Photo 10: Park & Stride facility at the edge of a park, five minutes from school S3 on foot

restrictions in front of the school gate proposed by the school board fell flat as well: *"The school tried to change the local road system into a compulsory one-way system, but local residents opposed. So now [there is] a voluntary one-way system, so all the burden is placed on the school."* (headteacher S3).

There is thus a clear role for the Council to intervene and play an active role in engendering higher activity levels among pupils, whilst simultaneously enhancing road safety. In addition, local authorities are responsible for ensuring children have access to safe and well-maintained pedestrian and cycling infrastructure. Nonetheless, they appeared to be unresponsive to the concerns of participating residents about the poor state of the roads around schools. *"My mum spoke to the Council about the uneven pavement, but the Council have still done nothing about it. They promised two years ago that after the development of school they would repair [the pavement]"* (I16_S3). A similar absence of governmental action was pointed out by pupils and accompanying adults in relation to crime and littering: *"He [the person cleaning the streets] didn't take the bins out! It's just left there. He should have taken all the rubbish out. But he just left it. You know, I was talking to that guy. I said: 'You have to do your job. They are paying you to do your job.' He said: '[The Council are] forcing me to do all this area', but you know sometimes, it's one week tills he cleans"* (mother I2_S1, *photo 11*). Given this lack of a prompt response from local authorities, it is perhaps unsurprising that other policies aimed at increasing levels of active transport to school have been unsuccessful, and that citizens feel estranged from, even abandoned by, their local public representatives.

Photo 11: Bin set on fire, with remaining litter after cleaner has passed

Beliefs

The key concept in the discourse on what constituted good parenting in relation to children's outdoor travel was supervision. Not only were accompanying adults deeply convinced of the need to permanently supervise young people along the entire commuting trajectory, the sighting of a child 'on its own' outside worried passers-by. *"Once, my sister and I, on our way to school, a random woman – apparently she worked at a school – she checked if we were OK.*

She asked me where my mum was. I said 'she's at home, she is not feeling well', but she said 'I'm gonna keep an eye out for you', but my mum was on my phone, so she was the one checking if I was OK, because me and my sister don't really need [the passer-by's] help" (I5_S3).

Whilst crime is thus a reality in the Borough and its risk should not be downplayed, stranger danger is now solidly rooted in the minds of London adults to the point where allowing a child to be unaccompanied is perceived as a lack of parental responsibility. This adult fear translated into the voices of the interviewees: *"It is not safe. […] Mommy says there's people who jump out of the bushes and catch children"* (I8_S1). Once again, this fearful narrative is stirred up by school sessions and media portrayals of London as a crime capital: *"We have got lots of murderers near our school. Sometimes we hear it on the news."* (I16_S1).

<u>Technology</u>

The final component of the ecological framework is the technological aspect of children's commute to school, closely intertwined with the materialised nature of this daily activity. The potential of smartphones to facilitate true interdependent travel for pupils was particularly notable. The reassuring idea of being able to reach or be reached by their daughters and sons resulted in a larger number of parents allowing, or considering allowing, their child to walk or cycle to school without adult supervision. At times, phones replaced the physical presence of the adult completely, as contact was constantly maintained along the route to school: *"I keep talking to her on the way. [...] I think, the last time she saw some boys doing silly stuff. So I tell her: 'Just ignore it, walk to school'. That['s] why I am accompanying on the phone"* (mother I1_S1). Similarly, Fitbits or similar activity-monitoring devices stimulate active commuting: *"I prefer walking to school because you get more fresh air and it's good for your health and I have a watch like the one my friends have, and every time you walk – it's called a Fitbit – you get more steps."* (I19_S2).

More traditional aspects of technology remain just as decisive in commuting outcomes. Children's defective bicycles were mentioned as a reason why they did not engage in active transport. At times, these had been damaged for well over a year without being repaired. As cycling is seen as a valid alternative to public transport or the car for distances around 1.5km, this lack of maintenance hampers children's active travel to school.

b. Activity component 2 of 2: The human ecology of children's outdoor, extracurricular sports and exercise

Whereas the commute to school is a set movement, undertaken twice a day, five days a week, offering pupils the possibility of implementing regular and structured physical activity into their daily routine, children's engagement in extracurricular leisurely activity is much more flexible and optional. Therefore, the human ecology of their participation in out-of-school sports and recreation in the public space is likely to differ from that of active travel to school. Hence, the habitat, population and behavioural vertices are explored separately for this second core component of children's extracurricular physical activity, starting from children's narratives constructed during the school commutes and guided neighbourhood tours.

It should be stressed that active commuting and extracurricular recreation are not always strictly separate entities, as children walking, cycling or scootering to or from school frequently engage in leisurely activity along the way. On the other hand, where recreation facilities are located outside of the immediate vicinity of the home, this involves a sometimes-sizable commute. Hence, drivers of, and barriers to, children's engagement in these activity components are bound to converge for various constituent elements of the human ecological vertices.

i. The Habitat Vertex

<u>The Built Environment</u>

Several built environmental characteristics included in the spatial epidemiological study emerged spontaneously as influential factors determining children's extracurricular activity patterns during the go-alongs. The proximity of easily accessible and diverse recreation facilities, in particular greenspace, was a main determinant of the frequency with which children participated in extracurricular sports and free play. Interestingly, this not only encompassed proximity to the place of residence – *"The most favourite thing about the neighbourhood is that the parks are, like, local, and it's not far away"* (I10_S3) – but also proximity to parks and playgrounds around school which fostered after-school activity. As one mother explains, *"we live in a flat, so we have no garden, so I prefer to stay [after school] an hour more in the park"* (mother I10_S2). Some children felt lucky in that regard, whereas others didn't, resulting in vastly different narratives. The contrast between *"I have loads of parks near my house and loads of flowers and [names park] near school'* (I7_S3) and *"Here, there's nothing"* (I1_S1) is striking. The importance of providing short routes to facilities was illustrated by a situation where a lack of proper maintenance of the public space was beneficial to a participant's activity, as a hole in the fence surrounding the nearby park considerably reduced the length of the commute to the facility's entrance: *"Now we can get to the park"* (I14_S1). In contrast, perceived remoteness might lead to the refusal to traverse a longer route to better, more diverse facilities, once again driven by parental time constraints: *"The big park, I also don't go there so much, because the big park is not next our house and mommy only walks to the park next to our house"* (I8_S1).

In the majority of cases, however, the poor maintenance and lack of diverse amenities for sports and play incited children and their accompanying adult to travel further in order to access a preferred, more suitable facility, defeating a purely distance-based logic. In Newham, for instance, children living close to Beckton District Park often disliked this space, as it was not tailored to their interests: *"Well it's just like wildlife: grass and beasts"* (I5_S1, *photo 12*). Hence, King George V Park, with its diverse playground elements, was preferred, though this added up to half a mile to the child's commute. At times, children were also physically prevented from accessing the nearest suitable recreation facility, forcing them to look for alternatives further away: *"There is this bit [patch of grass] at the back. We don't have access, it's only for the people living in those buildings, so we go to the park"* (I11_S1). Beyond recreation facilities and greenspace, various public amenities also have the potential to attract children to the outdoors, inciting active travel unrelated to the school commute. Community libraries and swimming pools were most frequently cited, encouraging walking, cycling or scootering through the child's home neighbourhood. These facilities also had a clear community-strengthening, social function: *"[I*

Photo 12: Beckton District Park, unsuitable for child's play

go to the library m]ost of the times once every two weeks, so I can return the books or meet my friends." (I18_S1).

Photo 13: A family moving out of London due to poor living conditions for children

Aside from proximity, concerns about traffic safety were also referred to as a driver of parental limitations to children's outdoor activity close to the road environment. *"I don't let them play outside by themselves, not in this area. I mean in any area I wouldn't anyway. [...] People drive so fast."* (mother I6_S3). Not only are children thus prevented from walking, cycling or scootering to destinations around the home, their unstructured play and sports engagement after school hours, on the weekend and during holidays is also curbed by the risk posed by motorised traffic. This regrettable situation drives certain families out of London: *"We worry about the cars. [...] We prefer to live in a small town or village. That's why I would like to sell my house as you noticed probably. Somewhere where there is better air and more green. Not the traffic."* (I11_S3, *photo 13*).

Not only when in movement did cars pose considerable threat to children's activity. Parked cars took up significant volumes of public space that ruled children out of the public space, as there was no room for them to play, or because they were scared of damaging vehicles: *"We can't play in front of the cars"* (I9_S1, *photo 14*). A notable exception to this absence of opportunity for children's free, outdoor play and exercise in the road environment were cul-de-sacs. These were perceived as particularly suitable for their physical activity due to the generally safer road conditions. As one dad described it: *"It's quite a quiet road that we live on. Like I said, it's a cul-de-sac, so you don't get any fast cars coming down, and people usually take care when they take corners, because there's blind spots and stuff."* (father I12_S3). Similar observations were made for one-way streets and home zones.

Photo 14: Parked cars rule children out of the public space

Irrespective of the proximity of public amenities, greenspace, and places for extracurricular sports and recreation to the home or school, these facilities need to be reachable for children by bike, scooter or on foot. Closely related to considerations of perceived and objective traffic safety, this raises concerns about the walkability of children's home and school environments, enabling them to access the outdoor physical activity opportunities available in the public space. While all included participants resided within walking distance of at least one park, playground or other type or public greenspace, the lack of walkable roads leading to these facilities frequently hampered their optimal use. Deconstructing Stockton's walkability index components, a dense network of intersections posed a particularly strong barrier to children's active travel to facilitate extracurricular sports and play: *"So there is another way of going to the park. But this is the way I tell him to go on the odd occasion that I let him go to the park on his bike, because you don't have to cross here [at a dangerous three-way intersection]. So the other way is a little shorter, but this is the way he knows, this is his way."* (mother I9_S1).

Despite the walk to the nearest park sometimes being less than five minutes, accompanying adults described the lack of safe and well-maintained pedestrian and cycling infrastructure as a reason to opt for motorised transport to reach public activity spaces. The result is a paradoxical situation, where bicycles and scooter are loaded into cars and driven to a park or playground within walking distance, thence contributing to the decreasing safety of the road environment. The supply of walkable and cyclable routes to public child facilities thus didn't match the demand: *"They don't have a bike lane and this is where lots of bikes come, they should add a bike lane around and locks for bicycles."* (I17_S1).

In contrast to the probing required along the commute to school, the foodscape spontaneously emerged as a driver of children's out-of-school active mobility unrelated to school travel. Corner shops, supermarkets and fish & chips or chicken & chips shops all incited participants to walk, and interviewees appreciated that they *"have all important shops close by, so we can walk to them"* (I2_S3). Ironically, the physical activity this entails often served to facilitate lengthy sedentary activities: *"When we are watching a film at home, we sometimes fetch popcorn in the corner shop"* (I22_S1). In all cases, the foodstuffs purchased comprised highly calorific products or meals: *"When we are hungry and there is no food home,* *we go to the chicken & chips or fish & chips shop"* (I22_S1). However, this buying of energy-dense products is often for want of a better, healthier option, especially in Newham, where children remarked on the food desert in which they reside: *"There are not much places where you can buy nice healthy food around here"* (I12_S1). These healthier products were solely provided in large shopping centres at the very edge of predominantly residential areas, inciting passive travel for the family, both by car and public transport, and mainly on the weekend when children could potentially be active elsewhere.

Confronted with the reality of the childhood physical inactivity epidemic in both studied Boroughs and across London, it is therefore worthwhile to consider alternatives which might perhaps not be the preferred solution of local public health teams, but could nonetheless contribute to an increase children's physical activity levels. The foodscape could play a key role in inciting this much-needed activity, as exemplified by the London Designer Outlet next to Wembley Stadium. At the entrance to the Outlet, an open-air playground is located, sheltered from the elements by a permanent, gazebo-like roof structure, as well as a coffee shop (*photo 15*). Both children and parents described their enjoyment of this place, as, following a visit to the Outlet, children could play outside, while parents supervised their offspring while enjoying a drink. Moreover, this form of 'cappuccino parenting' happened year-round, as the covered playground is accessible even in bad weather during winter months: *"We go there often, even in winter"* (I9_S3). Parental considerations and appreciation of this type of neighbourhood amenity were well-illustrated by this boy's mother: *"It is open, but under a roof. Which means that if it does start to rain, and even on days like today [early February] where you are like 'Shall I, shall I not', then that would be an option then, the better place"* (mother I9_S3). In addition, the presence of public facilities such as the Brent Library was an additional pull-

Photo 15: Covered playground (left) and coffee shop (right) next to London Designer Outlet

factor to this space. However, again, the foodscape surrounding this open space is decidedly obesogenic, as multiple children described combining play with getting an ice cream from one of the vans waiting around Wembley Stadium.

The final built environmental variable belonging to the habitat vertex included in the quantitative stage, air pollution, was mentioned significantly less frequently in relation to free, outdoor physical activity than was the case for active school travel. Moreover, references to this issue tended to be more generic and broader, most likely because this physical activity component was usually set in outdoor areas further removed from car fumes experienced as intrusive.

Photo 16: Fly-tipping monitoring in Brent

However, looking beyond vehicle exhaust, other forms of pollution struck children as depreciating their neighbourhoods. Littering was commonly perceived as deterring extracurricular play and exercise. The most prominent forms of environmental pollution mentioned by participants were fly-tipping – *"People leave stuff on the street, like they're trying to get rid of. Because maybe they don't want it in the house, and it's just in the way and it gets very annoying."* (I1_S3) – and dog faeces: *"It's a little bit messy, you know. A lot of dirt, and dog poo everywhere. Especially, in the park in the play area."* (I9_S2). The gravity of this problem was underlined by the 'Fly-tip monitoring' vehicles that could be seen in Brent (*photo 16*). Littering could be observed across the Boroughs: on roads and pavements, in porches, in ditches, on playing fields, in forested patches... Children linked these large volumes of refuse to a lack of bins and infrequent waste collection: *"There are loads of bins for the houses but none for the public"* (I11_S2). This lack of cleanliness, and animal faeces in particular, hindered children's physical activity in the outdoor public space and along routes to facilities: *"In summertime we sometimes play in the grass, and lots of dogs are there, so... Sometimes it's very bad"* (I9_S2).

Similar to the findings for active travel, children's recreational activity was also disrupted by noise from planes, trains, roads and construction works: *"The neighbourhood is noisy, always planes. It bothers me when I am outside."* (I7_S1). Whilst it should be noted that some children in Newham enjoyed looking at the airplanes taking off from London City Airport as a pastime, most children agreed the roaring planes detracted from their environmental experiences, as this disturbance impeded on social interactions with siblings, peers and adults: *"I have to raise my voice because people don't hear me"* (I6_S1).

The value of the go-along methodology beyond unravelling the context-specific dynamics underlying the objective associations observed in built environment-physical activity-body composition triad was again highlighted by the identification of new, inductively established themes emerging from children's narratives. The most frequently cited facilitator of children's extracurricular physical activity was the provision of a diverse free play and sports infrastructure. Upon asking participants about their favourite activity-related element in the home neighbourhood, swings, slides, roundabouts, climbing frames, football and cricket pitches, skateboard ramps, a BMX track and cycle paths were all mentioned. More broadly, greenspace and even simple, concrete squares close to shopping centres attracted children to the outside. These facilities were valued more if water fountains, public toilets, bins and bicycle parking were provided. This underlines the importance of catering to the varying needs and preferences of young Londoners, as no unique, homogenous pattern of preferred play and sports infrastructure could be identified.

Nonetheless, across all narratives, one common denominator for what constituted an attractive activity environment was repeatedly brought up by the children: its maintenance. *"There was this big slide but it was a bit broken, and so they took it out because it was a bit unstable, but they didn't replace it with anything"* (I14_S1, *photo 17*). The removal of equipment due to poor upkeep made it less likely children used the public space for their extracurricular activities: *"The park nearby, [...] the swings are gone now. That's why I think this park is sometimes boring"* (I8_S1). Especially in Newham, this lack of maintenance of facilities tended to be a structural problem: *"The climbing rack is broken. [...] I think for four years. It was broken when we first moved here."* (I17_S1), or *"My favourite used to be that* *one [pointing to a roundabout], but it broke and nobody uses it because it hurts their hands"* (I19_S1). This pushed children to make use of the few public amenities that were both in good condition and offered a diverse set of play and sports opportunities, often located further away from their place of residence. Accompanying adults related this lack of suitable and functional recreation infrastructure to the absence of children from the public space, also affecting social cohesion: *"I guess if there would be a little more play apparatus, then more children – because there's lots of children around – more children would come. But I guess it's more for dog walkers. As you can see…"* (mother I16_S3). The slow decay of the societal tissue in communities was thus accelerated by the poor quality of the public space, confining children to private spaces for their out-of-school physical activity – be it backyards, secluded playgrounds of apartment blocks, or indoor facilities requiring an access fee.

Photo 17: Poorly maintained sports and play facilities reduce children's physical activity

Children had clear reasons for their preference for specific facilities: *"There, I like the outdoor gym in that park and the cricket field with AstroTurf"* (I13_S3). Often, adventurous elements that present physical challenges such as monkey bars, parkour or public gyms, allowing children to briefly escape from the permanent supervision by risk-averse adults, were favoured. Even though public gyms are primarily aimed at adults, it was a dare *"to do all of them"* (I16_S2). Being ruled out of the road environment, parks increasingly became the refuge for children wanting to bike as well, as they can *"speed through it"* (I13_S3), unhindered by cars. Likewise, jogging and running are no longer activities primarily performed on pavements through the built environment, but restricted to running tracks and patches of grass.

<u>The Natural Environment</u>

Elements of the natural environment had a dual impact on children's propensity to engage in extracurricular physical activity. Whereas patches of grass hindered one child – *"It's really tall,* *it's like half my body size and you don't know if a dog pooped there"* (I4_S2) – another was fond of that same area – *"[I pretend] I am a savannah cheetah or lion"* (I2_S2). Nonetheless, participants overwhelmingly appreciated greenspace close to their homes. Trees, flowers and plants were extensively and lovingly described as we crossed neighbourhoods, and children happily travelled beyond usual walking distances to see small farm animals, ducks and ducklings, and tadpoles. The outdoor natural environment also offered valuable learning experiences, as a participating girl trying to cross a frozen pond discovered: *"I once did when there was ice on it. I walked on it and then I fell through it"* (I7_S2). Trees also replaced man-made infrastructure, adding to the materialised interaction of children with the nature that surrounds them and providing much sought-after physical challenges: *"Me and my sister used to go up there and found different ways to play there. You can hang on the trees and climb them."* (I4_S2, *photo 18*).

Photo 18: Trees present physical challenges for children

More contentious was the presence of dogs in the outdoor public space. Urban parks, greenspace and the roadside environment have become hotspots for human-dog interactions. While, at times, encounters with puppies or poodles were considered to be pleasant, most children openly discussed the anxiety they experienced when coming into contact with dogs, often based on traumatic events: *"Once it happened to me after school… me and my brother we were playing football and this lady came with this big dog. [The dog] started following us. I was running, and the dog kept on going on me, and then it scratched me in the arm and ripped my jumper"* (I17_S2). This restricted children's outdoor play: *"The reason we don't like to play here, is because of dogs come here and they do their business and because they are scared and when they come they scare the children, because if we swing they're scared because they think we're gonna hit them"* (I17_S1). One family driving to the nearby park even substantiated this choice of passive commuting to recreation facilities by a fear of dogs, as this would allow them to flee should an uncomfortable situation arise.

Beyond fauna and flora, weather and climate also impacted children's levels of extracurricular, unstructured physical activity. Due to its flexible and non-essential nature, the effect of poor atmospheric conditions on reducing children's free, outdoor play and exercise was stronger than the activity-deterring influence of precipitation, low temperatures and darkness observed for the compulsory daily school commute. *"In winter you have to wear hot stuff, it's raining all the time and we need to stay home"* (I8_S2). Nearly all children described a drop in physical activity during autumn and winter months to a level that can only be described as a form of hibernation, as children spent the lion's share of their out-of-school time engaging in completely sedentary activities, especially on the weekend. Even rare days of heavy snowfall during the interview period, when several participants excitingly engaged in the building of snowmen and snowball fights, were seen a reason to stay indoors for some, as it's *"windy and [there is] snow in my eyes. It's awkward"* (I8_S2). Being allowed to play outside in the snow at school then becomes an unwelcome obligation: *"It snowed and they* made *us go outside"* (I11_S1). However, these restrictions on going outside in autumn and winter were often adult-imposed, as children intrinsically would like to be more physically active: *"The day before yesterday, he was asking to play outside but it was just too cold so I said no and he did fight me to go to the park"* (mother I3_S2). While children who are active during winter months have been shown to be less susceptible to illness, the fear of getting sick and missing school as a consequence was brought up by accompanying adults as a main reason to prohibit outside sports and play: *"My mum is scared we catch fever or cold, and we need to maintain ourselves, so we only do sports in summer"* (I4_S2).

In addition, poorly maintained road and recreation infrastructure posed significant perceived risk, judged to make them inaccessible during episodes of bad weather. Icy pavements, mud and puddles don't match the risk-averse attitude to children's extracurricular activity observed in the interviewed sample: *"If you run you can slip"* (I7_S2). Moreover, children and parents alike expressed a dislike of mud stains, bordering mysophobia: *"There's a place where you can play football over there, but it's really muddy now"* (I17_S2, *photo 19*). Analogous to what was observed during the school commute, this slump in activity levels during autumn and winter was amplified by seasonal darkness. The reduced number of daylight hours not only incited children to stay indoors, but was also tied to shorter opening hours of outdoor recreation facilities and public greenspace.

Photo 19: Mud deters children from playing sports outside

<u>The Social Environment</u>

The presence of other children, be it peers or siblings, was a crucial factor stimulating extracurricular physical activity of interviewed young Londoners. Participants were delighted by playing and doing sports together with others kids, even if they weren't personally acquainted prior to the activity: *"Sometimes people let me play football with them in the park, I really don't know them, I just play with them"* (I7_S1). Outdoor activity offered a tremendous opportunity to forge new friendships: *"Whenever I go to the kids area, I meet children with whom I become great friends"* (I18_S1).

Despite the importance of these spontaneous social interactions, the presence of children in the outdoor public space is no longer self-evident: *"I think the park can be a good place for kids to play. You don't see that many kids playing. It's usually two-three kids and after a while they go back because nobody is coming out'"* (I8_S3). Only a handful of participants described episodes of independent outdoor physical activity, though even in these instances, intermittent parental supervision occurred: *"Mom watches me through the window when she is cooking [when playing in the playground near the house]. Once in a while she'll come and* *check me in the window"* (I15_S2), or: *"When they cycle outside, I wait there [indicates spot] till they come back"* (father I5_S2). The few caretakers 'daring' to let their children play outside on their own expressed their unease at this situation: *"The worry is when they are by themselves [in the park] and I can't be there"* (mother I19_S1).

This absence of young people in the public space resulted in parents who possessed the necessary financial resources seeking to enlist their children in semi-structured play and exercise with organisations such as the Scouts or sports clubs. There, social interaction is stimulated in a controlled and supervised environment, further limiting independent and free physical activity. For children from single-parent families, those of lower socioeconomic status, or families with multiple siblings, the opportunities to engage in joint play and exercise for a fee were significantly more limited: *"It's too expensive, it's too costly. And I have two, not only one, and I'm a single parent."* (mother I5_S3), and *"Here, there's not one single playground for kids to play. Only indoors, but that costs a lot of money."* (mother I9_S1). For parents who can afford them, these clubs and organisation do, however, hold the potential to contribute to children's year-round activity levels.

Whereas the presence of other children in the neighbourhood had a uniquely positive effect on stimulating children's out-of-school activity, stranger danger and people displaying antisocial behaviour in the public space instilled a sense of fear, thereby hampering free outdoor play and sports engagement, especially if unsupervised. This fear of 'the other' spanned a wide range of population groups and individuals, from flocks of teenagers claiming parts of playgrounds and parks, through people under the influence of alcohol and drugs and children and adolescents involved in gang violence, to angry neighbours or kidnappers. While this fear was expressed mostly in vague terms during the go-along interviews – *"There are some gangs around this area, there's*

Photo 20: Location of a knife crime incident pointed out by a participating boy

been couple of killings around this area" (I7_S1) – several children pointed out precise locations where they or their relatives and peers had been confronted with unpleasant experiences, especially in relation to gun violence and knife crime: *"It's quite dodgy around here. My brother and my neighbour went to the park, and on their way back, they got robbed by these two teenagers and one had a knife"* (I10_S3, *photo 20*).

These events often left a deep impact on children: *"I'm scared of people that might hurt me. I had experience: [when being in the park with siblings, without a parent] there was a man who was showing us on FaceTime to another person, and then we had to run"* (I13_S2). This resulted in unsupervised outdoor activity being further restricted by adults: *"His big sisters were there and they knew there was some potential danger. [...] So no, never since that day I said 'I don't leave you again alone'"* (mother I13_S2). On the more trivial end of the spectrum, the traditional image of the 'angry neighbour' also appears to persist: *"They made sure I can't play football anymore outside. They got my football."* (I12_S1).

Similar to what was found for commuting mode choices, the adoption and propagation of active, outdoor lifestyles by parents entailed higher levels of sports and play of their offspring. This positive role modelling was, however, often curbed by time constraints: *"Dad can't really come to the park anymore because of a new job"* (I4_S2) and *"I don't have much time to take them there [to the park], because I work and go to Uni"* (mother I15_S1). This situation, whereby children's physical activity was dependent on the availability of a parent, was closely intertwined with the perceived need to constantly provide adult supervision, which has become an integral part of the care for and education of children: *"My parents are always there when we go to the park. Just to keep me safe."* (I5_S2). This internalised urge to continuously assess the safety of the activities in which children engage, as well the environments in which these activities are set, resulted, perhaps unsurprisingly, in a complicated exercise whereby parents tried to squeeze their offspring's recreation into their complex patchwork of daily responsibilities. The ensuing shortage of time or lack of enthusiasm frequently meant children were bound to the confines of their home after school and on the weekend.

While organising the school commute was primarily the responsibility of mothers, fathers appeared to play a more prominent role in facilitating their children's extracurricular recreation. This is either a shared task between parents – *"Mum and dad learnt us to cycle with a stick of a broom. They ran like a crazy maniac, let me go [and] I cycled on my own with a broomstick on my back"* (I9_S3) – or a traditional, gendered performance, whereby dad is in charge of the more adventurous aspects of children's upbringing, challenging his kids and teaching them new skills whilst providing a sense of safety. One child highlighted how cycling with his father strengthened his self-confidence, whereas an interviewed girl enjoyed spending time with her dad on the weekend, because *"Dad has a membership of the swimming pool, and yeah, with our dad it's really fun, because he likes to throw us"* (I13_S3).

ii. The Population Vertex

Several of the confounders included in the spatial epidemiological study that belong to the second vertex of the tripartite human ecological model – population characteristics – emerged from the go-along interviews as key determinants of children's outdoor, extracurricular physical activity. Age could be interpreted as a proxy of perceived maturity, with older children being granted more freedom to be independently active, thereby also expanding the perimeter of what they considered to be their neighbourhood. As a ten-year-old girl said: *"My mum started letting us go to the park by ourselves now, because we're old enough. But she used to follow us wherever we go before. It's always safe…"* (I13_S3). As children grew older and neared the age of adolescence, this went hand in hand with a change in activity preferences. Particularly those interviewees aged ten or eleven indicated that they felt they had outgrown child-centred playgrounds, while at the same time not having any teenage-focused facilities at their disposal where they could 'hang out' and spend time with their peers: *"If you like have my age or a little older, you don't want to go in the gym, but you don't want to go in the children's area in the park. Maybe they should make like, a teenager place. [...] I guess there should be benches, where you can sit."* (I4_S2). This desire to spend more time with peers was also gendered, with girls preferring to talk with their friends undisturbed, as opposed to the active engagement in team sports favoured by their male counterparts. These findings underline the need to provide diverse recreation facilities tailored to the needs of boys and girls of all ages.

Similar to what was observed for the commute to school, during the interviews, no reference was made to ethnicity by participants and accompanying adults. No distinction could therefore be made between the out-of-school activity patterns of children of different ancestries based on their go-along narratives. Similarly, the relation between the various body shapes of included children and their self-declared levels of extracurricular physical activity was ambiguous. On the one hand, for two children whose fuller body shape arose during the interview, their preference of low-intensity or sedentary activities was explicitly mentioned: *"So we can play in the summer in the backyard, to keep him away from the TV"* (mother I9_S1), and *"We get our bikes and they [siblings and friends] have a race and I'll be a judge watching them, because my bike is a kind of small and my legs a kind of hurt when I do it a lot of times"* (I17_S2). In contrast, another boy with excess weight was an avid rugby player, participating in freely provided training sessions in Newham multiple times per week: *"It's two hours, and it's for free. And my main teacher in rugby, he was a professional player – he was centre-back, which is number 9. And I wanna be a rugby player, but I wanna be number 2 which is a hooker."* (I14_S1).

Aside from these predefined themes, the abductive data analysis allowed the importance of gross motor skills in physical activity decisions to be inductively established. The collected narratives showed that higher levels of specific motor skills – such as the ability to cycle – contributed to children's enjoyment and frequency of engagement in these activities. As was observed for active commuting, strong disparities in spatial awareness could also be noted, with children reporting lower levels of outdoor activity remarking on their lower geospatial acquaintance with their surroundings. Most strikingly perhaps, upon entering a side-road on the way to the nearest area of greenspace within 200 metres from the participant's home, an interviewed boy turned to his sister and inquired: *"Are you sure [about the route]?"* (I17_S2).

iii. The Behaviour Vertex

Social Organisation

Photo 21: A denser urban environment stimulates social cohesion

The first component of the third ecological model vertex, behaviour, explores the societal structures that stimulate or hamper children's outdoor, extracurricular activity levels. Above all, it was clear that the interviewed children intrinsically longed for a cohesive social network in their local area, consisting of peers to play with, friendly neighbours, and familiar faces across the neighbourhood. In the rare cases such network could be observed in Newham and Brent, this fostered participants' outdoor physical activity, as well a sense of belonging to the local community. This was primarily noted in more dense urban environments where children lived in closer proximity to each other: *"Everyone is friendly. [...] Well, there are a lot of kids who live in the buildings, so that means I have lots of friends at school and here"* (I18_S2, *photo 21*). In contrast, a lack of social tissue entailed a lack of trust, especially among parents, as highlighted by this accompanying mother: *"I think people are worried about who their kids… people don't know each other, so the kids… meeting other kids, like, who is he, what are his parents like, you know, you're always asking questions."* (mother I10_S3).

The emergence of freely flowing interactions stemming from an organically grown local social network was also found to be thwarted by the societal pressure for children to be continuously working on their personal development – whether physically or intellectually. The list of children's engagement in supervised and (semi-)structured extracurricular activities was endless, and children often expressed their utter despair at the packed schedule in the week following the interview, as this ten-year-old girl underlined (I13_S3):

"Me and my twin sister play the violin, and all three of us play music, and all three of us dance as well, like classical dance. And on Tuesday, we have English teaching, we come home late, and then Wednesday, I have a language club. Then I have basketball as well, I come back home late, and then Thursday I'm free finally, and then Friday, I come from school, and

then I have maths and then I go to sleep. And then on Saturday, I have violin, I do yoga, I come back home and I'm free and then on Sunday, I have language club."

The overdose of booster classes, music and dance lessons, and structured sports activities is exhausting, and rules out a simple visit to the park. Parents who possess the necessary financial means have become their child's personal assistant, cramming in as many extracurricular activities as possible and dealing with the logistics of ferrying their offspring around according to a tight work-play-sleep timeline. The rare downtime children are granted is then spent on family trips to supermarkets or shopping malls, though most children simply searched for the nearest couch and engaged in sedentary, screen-based activities.

A shift in societal attitudes towards domesticated dogs acted as a further deterrent of children's outdoor physical activity. These animals have become distinctly humanised, and dog owners claim the public space they perceive as necessary and rightful for the wellbeing of their individualised pets, often at the detriment of the space for children. The resulting human-dog conflicts, amplified by the vast volumes of dog faeces observed during the go-along interviews and the rude attitudes of adult dog owners, made children feel anxious and unwelcome in the outdoors, with parents taking sometimes drastic measures: *"We go by car to the park because sometimes we see people with dogs which are not very nice. [...] And I worry because of the children. [...] It's very walkable but that's one of the reasons why we go by car. [The dogs] have to stay in the fenced area but sometimes people are not good with their dogs and they think the dog becomes before everyone else. And you see, sometimes my idea of safety, I think if anything... we get in the car."* (mother I4_S3). These fears are amplified by children's smaller stature, placing them closer to the height of dogs.

Photo 22: 'No Ball Games' signs remove children from the public space

Policies implemented by local authorities therefore have the potential to protect the place of the child in the outdoor environment, or to further rule them out of the public space. A striking example of the extent to which the city is tailored towards the needs of adult members of the population, is the presence of 'No Ball Games' signs in open spaces close to children's places of residence across both Brent and Newham (*photo 22*). *"In our area, we are not allowed to play ball games, because people are thinking about their cars"* (I9_S1), or *"The people, London Council, came and tell: 'Not allowed to play football anymore'"* (I12_S1).

Similarly, the Borough has a responsibility to provide adequate and well-maintained recreation facilities for children of all ages, in close proximity to their place of residence. This, however, was not always the case for interviewed children, particularly in Newham: "*I always tell him [participant] maybe in secondary school he will be slim, because he is always stuck at home. Sometimes you wish them to come out. I hope and pray… they [Newham Council] could do something for the kids as well instead of measuring them."* (mother I9_S1).

In analogy to what was found for active commuting, Council efforts to prevent and tackle high levels of crime in the Boroughs, combined with the portrayal of criminal events in the media, impacted the perception of the public space and subsequent physical activity decisions for children. The two most common crime-related reasons why children felt uncomfortable while being active outside, were the perceived risk of knife crime – *"It might be a bit silly, but basically, on the news, there's a lot of killing and stabbing and stuff. So I don't feel comfortable going to sleep there."* (I8_S3) – and burglaries: *"[There are] signs for criminals on the lamp posts, but you don't see them very often."* (I5_S2).

Schools also bear a responsibility towards ensuring children can undertake physical activity outside of school hours. In particular, the volume of set homework determine the possibilities of pupils to engage in outdoor physical activity. A nine-year-old girl mentions: *"I play rarely in the little square because we have so much homework. We have to work all the time, so there is no time."* (I15_S1), while a boy aged eight tells me: *"Playing is after it [homework] is finished or during the holidays"* (I2_S1). Moreover, physical activity is often limited to the opportunities of affordable and accessible after-school clubs, because *"If there is no school, he does no exercise"* (I9_S1).

Photo 23: The closure of local public facilities is detrimental for children's activity and social networks

Policies can also have secondary, activity-restricting effects. School admission policies resulting in children having to attend schools that are located far away from their home, implies they face longer commutes and are less likely to have local friends, limiting their opportunities for extracurricular physical activity with peers. Analogously, the centralisation of public facilities such as libraries and swimming pools creates hotspots of recreation opportunities, for instance around Wembley Stadium. However, the consequential closure of (community) libraries in other parts of Brent removed vital opportunities for the creation of a social network and active commuting to these places. *"Now it's going to be shut down. It used to be a library, and then it became a community library, and there's been people saying they're gonna shut it down and they're gonna build apartments."* (I4_S2, *photo 23*). Well-intentioned school policies, for instance bringing library books directly to schools in an attempt to stimulate reading among pupils, might have similar, detrimental effects. Nonetheless, positive examples were also found: several parents making use of the Park & Ride provision in northern Brent when picking up their children after school allowed them to play on the nearby playground before heading home in summer.

Beliefs

Perceptions of risk and unsafety were deeply embedded in the risk-averse extracurricular activity narratives of interviewed children and their accompanying adults, driven by restrictive school and Council policies and the highly dramatic portrayal of crime in local and national media. Institutionalised fears and anxieties – of dogs and foxes, of road accidents, of knife crime, of injuries while playing outside, of reduced productivity due to weather-related illness... – led children to avoid specific activities, or to adopt an overall sedentary, indoor lifestyle. Despite often being non-materialised and intangible, especially in the case of stranger danger – *"It's a secure part of the city, but still… You cannot trust them to be out by themselves"* (mother I4_S1) –, this fear incited participants to take risk-minimising precautions: *"This is the area in the park we always avoid unless we're on bikes and we're all together"* (I1_S3).

Adults acknowledged their concerns could be exaggerated: *"Perhaps it are preconcepts but I don't allow them to go there without us, not that it is super unsafe"* (mother I9_S3). However, in a single case, a parent managed to take a more non-alarmist approach: *"In terms of people safety we never had any concerns, although there have been robberies around, but that's anywhere"* (mother I11_S2). In spite of this occasional realism, the 'mens sana in corpore sano' credo appears to have been abandoned in favour of a developmental view centred around children's intellectual progress and helplessness. Maths and languages form the basis of children's extracurricular schedule, not the gaining of motor skills or spatial awareness.

<u>Technology</u>

"On Saturday, I wake up, I eat my cereals, I play on my phone, I watch YouTube, I see if my cousin is there, and then I go and play Fortnite like normally" (I14_S2). Nearly all children referred to smartphones, tablets, personal computers or game consoles as their main extracurricular pastime. When meeting parents and children in the morning prior to school or on the weekend, they were frequently watching television, which regularly kept on playing as I explained the purpose and methods of the interview to the child, providing continuous background noise. Especially during autumn and winter months this fits the image of the London primary schoolchild as a hibernating individual. *"It's winter now, and I can't go to the park, because all the objects are really cold, and I catch a cold like, very often. Like, I would, normally, sit down with him [brother], and watch iPad or TV."* (I15_S2). Participants indicated spending multiple hours per day watching TV, playing games or browsing the internet. Time indoors was thus not spent together with family, siblings or peers engaging in joint activities. Children *"just don't go to the park anymore, they are just with their electronics"* (sister I4_S2). Technology could, however, also play a positive role in stimulating children's outdoor activity, in particular in relation to generating a feeling of safety through surveillance cameras. Nonetheless, accompanying adults still preferred in-person supervision.

As was the case for active commuting, traditional technological issues curbed the activity levels of children as well, especially broken bicycles. Mechanical issues impeded children from engaging in voluntary, leisurely cycling. One mother, when asking her son about reasons not to visit the nearby park, interjected: *"The tyre of the bike is broken and I don't have time to fix it"* (mother I9_S1).

V. Children's lived built environmental experiences: discussion and policy proposals

Participants' accelerometry and activity diaries pointed towards high levels of physical inactivity, especially after school and on the weekend. Children's narratives then revealed that the little activity that took place during winter months tended to be structured and set in supervised environments. The go-along interviews provided powerful microlevel evidence on context-specific drivers of, and barriers to, extracurricular physical activity in the public space in Brent and Newham, affecting children's mental and physical health and wellbeing.

The wide diversity of personal, lived experiences shared by participants during the interviews thereby substantiates the objective accelerometer data and the contextualisation provided by the activity diaries. Bringing these rich and varied datasets together now enables further reflection on several of the key themes underpinning this study which were explored in the conceptual framework, notably the role of place, physical activity, and the child. Moreover, the fieldwork highlighted the importance of context, ignored all too often in previous studies, and incites a careful consideration of the selected research methods, which heeded the call for novel techniques to explore the triad of the built environment, children's physical activity, and body composition. Therefore, each of these aspects is examined in this discussion, followed by the translation of my qualitative findings into concrete and grounded policy recommendations, stemming directly from children's expert voices.

a. Place, physical activity, and the child: conceptual insights from the qualitative study

i. The vital role of place

Children's perceptions of what constituted 'their neighbourhood' were far from universal. The interviewed pupils did not abide by fixed geographical delineations provided by spatial-administrative units. In contrast, their perceived neighbourhoods differed vastly based on children's varying degrees of freedom to be independently active, modes of transport to a wide range of facilities in their surroundings, and frequency with which these facilities were used. Moreover, man-made or natural physical obstacles and subjective built environmental and societal barriers in the outdoor public space influenced the size and shape of the neighbourhood.

This heterogeneity, preventing a straightforward delineation and definition of London primary schoolchildren's neighbourhoods, was closely tied to their sense of place and materialised and grounded movements and mobilities across the urban environment (Sheller & Urry 2006). Participants' accounts of the multiple and changeable built environments in which they dwell, commute and recreate demonstrated that the characteristics of their immediate surroundings directly impacted their outdoor, extracurricular physical activity decisions. These decisions tended to be more strongly influenced by the physical, socio-political and economic structures in which the child and her or his family were situated, than by their personal preferences or individual characteristics. Their levels of physical activity were eventually determined by the provision of adequate built environmental resources in the public realm, themselves closely intertwined with, and the result of, urban planning and school and local authority policies.

The myriad ways in which the physical surroundings affected children's activity choices differed according to the specific component of extracurricular activity that was examined. For active commuting to school and other neighbourhood destinations, including parks and public facilities, proximity and road and personal safety stood out. Perceptions of risk were thereby often rooted in the real-life, materialised experiences of children with unsafe environments along their commuting routes, and not simply the outcome of a merely subjective and exaggerated fear that does not match the objectively determined reality. As observed by King and Sills-Jones in the UK (2018), these high levels of fear result in children proactively being kept away from the 'dangerous' outdoors, or placed in a glass house. They are supervised at all times, and bounded by clear constraints limiting their action radius and the range of activities they are permitted to engage in by the 'responsible' adult. The importance of the constant availability of an accompanying adult alongside the presence and support of peers and siblings acting as role models thus played a particularly strong role in determining physical activity outcomes, matching the findings of earlier studies on this topic

(Reimers et al. 2019; Schoeppe et al. 2015). Children's enjoyment of the presence of a travel companion, and parents' socially inspired reluctance towards the independent mobility of their offspring – with children outside on the street on their own described as *"street kids"* (mother I10_S3) – underlines the need for social facilitation of the active commute.

Walkability also surfaced as a crucial factor, though in a conceptualisation that strongly diverged from Stockton and colleagues' (2016) notion. Two crucial, child-specific components emerged that are not considered in traditional walkability models. Firstly, due to the car-centred development of the road environment in London, the child's active commuting space is restricted to pavements. These are living and thriving spatialities where embodied and materialised encounters occur with plants, animals, weather elements and 'the other', including peers, family and strangers. These encounters can engender anxiety and fragility, either concurring or rapidly alternating with emotions of enjoyment, even enchantment. Therefore, the provision of safe, well-maintained pavements is crucial, especially as children indicated being more prone to injury than adults, in particular when using their bike or scooter. Secondly, in contrast to Stockton's Walkability Index for London adults, a high density of crossroads acted as a deterrent for children's active commuting. Indeed, the presence of cul-de-sacs and home zones with low volumes of slow-moving traffic, connected via clearly visible and safe intersections, proved to increase children's sense of safety when commuting (Brockman et al. 2011; Gill 2007). However, some components of Stockton's adult Walkability Index were applicable to the perceived walkability of neighbourhoods for participating children. In line with the hypothesised importance of a diverse land use mix, the gentrification and the relocation of facilities and services to redeveloped urban cores out of sync with local needs across the Boroughs posed particular concerns for children's physical activity and personal development (Brown 2017).

Whereas the street environment, and pavements and crossings in particular, were the key spatialities determining whether children would walk or cycle to destinations, extracurricular free play and sports engagement in the outdoors tended to occur at a safe distance from roads. Primarily set in protected, secluded parks and playgrounds in the absence of motorised traffic, this second core out-of-school activity component was found to be stimulated first and foremost by the provision of adequate man-made or natural play and sports opportunities close to the home. The fact that these facilities could be accessed free of charge further increased their attractiveness. Participants highlighted the need to keep these places tidy. Indeed, waste management is vital in dense, inner-city environments. This is particularly the case in more deprived areas such as the southern part of Newham, as lower neighbourhood socioeconomic status has been associated with higher volumes of littering which, in turn, have been linked to health hazards for the general public, as well as antisocial behaviour and crime (Hastings et al. 2009), acting as barriers to children's outdoor activity.

Clean, diverse and physically challenging play infrastructure or natural elements then present participants with an opportunity to briefly act independently of their accompanying adult, making decisions about how to use their body to deal with structural obstacles, and reclaiming their space in the urban tissue as actors in their own right. Taking on these playful environmental challenges thereby results in many benefits for the child's wellbeing: higher levels of physical activity, improved independent decision making, and the significant development of motor skills, observations matching the literature on parkour (Gilchrist & Wheaton 2011). The latter is a form of 'lifestyle sport', whereby an individual moves through predominantly urban environments in a fluid manner, overcoming various human-made or natural hurdles – something children spontaneously did when being active in the outdoors outside of school (Veitch et al. 2007).

While these structural push- and pull-factors to children's core physical activity components in their neighbourhoods could thus be identified and potentially managed by local authorities, schools and communities, children's narratives, accelerometry and activity diary data illustrated their annually recurring hibernation during autumn and winter months (Tucker & Gilliland 2007). The ensuing seasonal restriction of children's outdoor activity spaces implies that the definition of the 'neighbourhood' not only strongly differs between children, but also varies throughout the year for each individual child.

Two fear-related factors could be singled out as key catalysts of children's sedentarism during this time of year, and should be mitigated to maintain year-round, healthy levels of active travel, play and exercise. On the one hand, children and adults believed that, by staying indoors, they minimised the odds of a child falling ill and missing school or other extracurricular activities. This belief is widespread (Ergler et al. 2013), although from a biomedical point of view, sedentary behaviour during autumn and winter impairs child health (Bento & Dias 2017). On the other hand, children feared darkness, and the lack of daylight limited the time they could spend in the public space. Children frequently experience phobias, and darkness-related anxiety is common (King et al. 2005; Williams et al. 2005). Interviewees also felt similar distress as a consequence of unpleasant encounters with animals, primarily dogs and foxes, severely impacting their daily activity choices. Again, the importance of social facilitation in mediating these environment-activity interactions, through the presence of and interdependencies with parents and peers, is crucial (Reimers et al. 2019).

The complex interplay of these materialised fears and anxieties, the unique characteristics of local populations, and the structural sociocultural and economic barriers observed during the go-alongs in Newham and Brent highlight the need for a holistic built environmental approach to tackling children's inactivity. In so doing, the notion of 'place' should undeniably be situated at the heart of any policy or intervention, recognising the set of micro-level physical, social and natural environmental barriers and stimuli at play. Unless these are appropriately addressed, children will remain bubble-wrapped (Malone 2007), having only few independent interactions with their environments and constrained to small mobility ranges, with the accelerometry and activity diaries continuing to show an excess number of sedentary hours during which participants engage in predominantly screen-based activities.

ii. The limited societal value attached to children's physical activity

The finding that only some ten percent of children included in our sample meet the WHO activity guidelines of a minimum of one hour of daily MVPA, with not a single child indicating that they had played outside every day of the week following the go-along, illustrates that physical activity was not a top priority for the majority of participants nor their parents. While concerns about the built environment, time constraints and weather conditions most certainly contributed to this outcome, pupils' narratives highlighted a more structural and concerning issue: from a young age, more weight is being attached to children's academic achievements than to their physical development. This is paradoxical, as childhood activity has been linked to higher academic achievement (Singh et al. 2019).

Placing the child's voice at the heart of my study proved pivotal in unravelling the drivers of this trend, as the language used by participants showed that this excessive attention to academic performance was primarily adult-imposed. Children themselves frequently indicated that they would prefer higher activity levels. Parental preferences for and expectations of children's intellectual development during out-of-school hours put significant strain on schools to not only fulfil their duty as education providers, but also to ensure children meet minimum activity levels and adopt healthy lifestyles. This view was reinforced by the observation that participating pupils collected well over half of their daily physical activity during school time. However, physical education and free playtime during school hours have themselves come under relentless pressure, limiting structured – let alone free and unsupervised – physical activity during children's daily routines (Ridgers et al. 2006).

The consequential reduction in children's energy expenditure increases their risk of overweight and obesity. In that regard, it was striking to observe that parents who described their child as having excess weight tended to be more aware of the importance of daily activity, while these children highlighted their bodily limitations when walking or cycling to school or engaging in extracurricular recreation and sports.

iii. Children's presence in narratives versus their absence in reality

The go-along interviews subscribed to the structural juxtaposition of the absence and presence of children in urban planning and mobility debates and practices established in the conceptual framework (chapter 2). In academia and (inter)national policy, children are often recognized as active citizens with independent agency and specific needs and rights, whose opportunities for physical activity in the urban realm are deemed important. However, children's narratives in Newham and Brent highlighted that, when policy is translated in practice at the level of local government, the child is marginalized and disappears from the narrative and interventions (Karsten 2005). The outdoor built environment of Boroughs still is not tailored to reflect and respect those needs and rights of children in the public space.

Moreover, the fact that children's voices should be heard and consulted in ways that differ from standard adult citizen participation has not yet penetrated local urban politics and policymaking, or remains only in the earliest of stages. As a result, children remain excluded from urban planning and, by extension, the urban environment (Derr & Tarantini 2016). Nonetheless, the active engagement of policymakers could contribute to ensuring this translation of the policy narrative into practice. Through my direct engagement with Borough Councils, for instance, children's voices were directly transferred to impact policy decisions and planned interventions. While I recognise the crucial role of parents in influencing the interdependent voices and practices of their offspring, placing children at the heart of my qualitative research and viewing their built environments through their eyes – also literally – makes them highly visible and influential agents, directly informing and contributing to these policies and interventions. These can, in turn, also impact parental perceptions and role modelling, creating bidirectional interdependencies. The attention for children's multiple built environments then successfully removes the stigma attached to family-based interventions, and has the potential to provide more inclusive and bold pathways to tackling childhood overweight and obesity.

b. The importance of contexts and methods

The go-along interviews highlighted the importance of the complex and multifarious microlevel contexts in which children's daily movements and activities are set in determining their physical activity outcomes. Zooming in to the scale of individual participants' lifeworlds in Newham and Brent, specific poorly maintained playground amenities, uneven pavement sections, individual scary dogs, uniquely dangerous parking exits... were all pivotal to understanding how small-scale built environmental elements impacted commuting and extracurricular activity decisions.

These contexts were not static: there was significant hour-to-hour, day-to-day and year-to-year temporal variation in the effect size of each of these determinants, related to seasonal variations, policy cycles and sporadic changes to the built environment. The lived histories of places also coloured children's narratives, creating positive or negative memories. The stabbing incidents occurring throughout the interview period, for instance, produced a tangible sense of fear and shaped children's everyday experiences and stories, closely intertwined with the spatiotemporal context in which the interviews were set (Leitner & Kounadi 2015). These thereby created an affective atmosphere that could not be objectively gauged or included as a confounder in statistical models. Place-based physical activity research then becomes increasingly crucial to tackle the childhood inactivity epidemic and contribute to children's physical and mental health and wellbeing (Vanaken & Danckaerts 2018).

The necessary insights can be gained by studying microscale geographies with the additional dimension of time (Leitner & Kounadi 2015). This implies the selection of the appropriate combination of research methods that warrant the collection of accurate qualitative data, enabling the design of policies and interventions to increase children's outdoor, extracurricular physical activity. In my study, participants and parents were very enthusiastic about the prospect of the walk- or drive-along: *"He looked forward to today. He was ready by 7am without asking, which is very exceptional."* (mother I18_S2). *En route*, pupils in the sample appeared to be eager guides. Their role of local expert in charge of the interview resulted in the majority of children providing a continuous and freely flowing stream of observations about the neighbourhood, destinations to be visited, and suggestions of how their environments could be improved.

The wealth and detail of the collected information was bolstered by the setting of the go-alongs in children's usual environments, ensuring they felt at ease and limiting the range of potential biases that might have occurred if children were confronted with less familiar surroundings (McCambridge et al. 2014). The informal nature of the go-along, with children leading the way and the interviewer-interviewee pair crossing the neighbourhood together, transformed the interview into a casual conversation. As time went by, participants frequently appeared to forget that they were participating in academic research, and their initial concern about giving the 'right' answer – *"I know the answer to all your questions!"*, as one boy (I2_S2) exclaimed at the start of the interview – quickly evaporated.

Nonetheless, and as theorised, their voices were a reflection of multiple, partial voicings (Rautio & Jokinen 2015). This was even recognised by accompanying adults: *"I can imagine that a lot of what he says, or what other kids say, is influenced by their parents. Because I often say there's no bins and I heard he mentioned that as well today."* (mother I2_S1). The presence of the accompanying adult, invited for research-ethical reasons, thereby presented an excellent opportunity to explore these influences, unexpectedly contributing to the potential to deconstruct children's narratives. Some accompanying adults proved to be more concerned about providing the socially acceptable answer and second-guessing what the researcher was after, interjecting if they perceived their child's observations to be 'incorrect', adding information upon completion of the go-along, and even sending post-interview emails: *"By the way, we eat this [fruit on the table offered to the interviewer following the go-along] every day when they come back from school, not just now. [...] It's not just us trying to pretend to be healthy"* (mother I11_PP19). This resulted in highly revealing, and at times passionate, discussions between participants and accompanying adults, highlighting the relative independence of children's voiced opinions.

Combining go-alongs with objective accelerometry and activity diaries showed the strength of the multimethod approach to answering the second, qualitative central research question, simultaneously allowing the verification of children's narratives and thus further overcoming response bias. The various methods offered different perspectives on the same research question, and highlighted the partial scope and suitability of each method (Moss & Haertel 2016). Combining the three data collection techniques thereby assisted data triangulation, and balanced out the weaknesses of individual techniques.

These weaknesses emerged during the fieldwork, and several limitations should be recognised. First, the group of applicants indicating their willingness to participate in the study was self-selected. However, the use of the maximum variation sample selection strategy based on the parental questionnaire allowed to limit the potential bias this entails.

Next, during the go-alongs, the accompanying adult was asked to refrain from actively participating in the interviews. However, several parents, siblings or relatives couldn't resist intervening and sharing their own opinions. Nonetheless, as highlighted above, this proved to be highly insightful, and underlined the fact that children's narratives were both interdependent and independent. In addition, this allowed insight into the built environmental perceptions of adults. Only in rare cases did this interjection interrupt the flow of the conversation, or did the child appear to be affected by the disturbance. Mostly, this stimulated debate or clarification, which unveiled participants' in-depth perceptions of drivers of, or barriers to, physical activity in their outdoor surroundings.

Third, the use of the go-along interview technique on public transport was more problematic. The noise, presence of strangers, high volumes and turnover of commuters during rush hour, and the sometimes-significant waiting times causing stress were not conducive to a smooth conversation.

Regarding accelerometry, fourthly, participants had overall high compliance with wearing the device. Only four out of 57 children did not meet weartime minima, of which two cases were caused by a faulty battery. As data were not transmitted in real-time, this resulted in a loss of information that only became apparent upon conclusion of the week of accelerometry. The lack of accurate measurement of swimming or cycling was corrected for through the use of activity diaries. The low frequency with which participants indicated participating in these sports implies the omission of these data from objective accelerometry did not significantly impact the overall pattern of observed physical activity throughout the week. Children did, however, provide vastly differing estimations of the duration with which they engaged in activities. This demonstrates their judgement of time was inconsistent (Allman et al. 2012), and could therefore not be used in the data analyses.

Finally, applying this combination of quantitative and qualitative research methods was highly time- and resource-intensive, and required me to master a wide range of research skills. Whilst the micro-level exploration of children's lifeworlds, combined with accelerometry and activity diaries, was pivotal to obtaining the necessary insights into the drivers of, and barriers to, children's out-of-school activity, using these methods was incompatible with shorter research cycles.

c. Environmental policies rooted in children's expert voices

"How are you going to make the community better?" (I15_S1). This pertinent question by a nine-year-old girl from Newham re-centres the focus of this discussion paragraph on the political intentions of this study, set out in the conceptual chapter. Children's accounts of lived experiences in their built environments and their suggestions about ways to tackle these were powerful and at times deeply moving, and can therefore contribute to meeting this political aim. This calls for a radical, bold change to traditional adult policymaking and politics,

stepping away from often inaccurate assumption of children's needs and wishes, and moving towards evidence-based policy directly informed by and reflecting the opinions and suggestions of young citizens.

The go-alongs showed how local school, Borough and city-wide policies actively or unintentionally ruled children out of the public space, thereby shaping their behavioural patterns, lifeworlds and, eventually, bodies. The narratives of the child-experts can now be used to reshape these policies, enabling young Londoners to reclaim their rightful place in the urban environment. In so doing, the key challenge is the translation of these accounts in such a way that they are taken on board and acted upon by policymakers (Sarti et al. 2018) – and the pressure is on: children and their relatives expect and demand research to make a difference.

It is therefore insufficient to simply include some policy recommendations, tucked away at the end of this chapter, if, as a researcher, I am truly interested in seeing my findings being applied by policymakers (Renkl 2013). I bear a responsibility to proactively undertake steps to bridge the gap between research findings and policymaking. The most effective strategies to that end, are partnerships with public actors (Brownson & Jones 2009), supported by clear and straightforward communication. To that end, I reached out to the Public Health Departments of Newham and Brent Council, and, upon gaining their support for the research, produced two tailormade, accessible policy reports for the Borough Councils of both local authorities, included in *Appendices 5* and *6*. Besides presenting my findings at schools to participants, parents and other interested pupils and adults to gain feedback and gather further policy ideas, these reports resulted in my active engagement in discussions with the Public Health policymakers in both Boroughs.

Moreover, I was invited to provide expert evidence to the Brent Council Obesity Scrutiny Task Group and the Councillors for Community and Wellbeing, and Public Health and Leisure, laying the foundations for a new childhood obesity strategy published in 2020. The findings from the second stage of the exploratory sequential mixed-methods design thus directly contributed to shaping local physical activity and childhood obesity policies. In addition, I was granted the opportunity to present my findings at multiple Borough-wide conferences on the wellbeing of schoolchildren, where I received valuable feedback on my work whilst having an opportunity to directly engage with those who could benefit from my study. The findings of my study were further shared on social media – especially via Twitter and blogs – by participating schools and Borough Council representatives. The evidence and policy proposals presented now need to be taken forward and implemented by Borough Councils, who have a moral obligation to promote child participation in the decision-making process around policies that will have major implications for their spatial practices and wellbeing-related behaviour, including their daily use of the outdoor public space (Bishop & Corkery 2017).

The policy recommendations listed below, rooted in participating children's voices, are the summarised version of the full recommendations included in the reports for Newham and Brent, and are tailored to the Borough in which they ought to be implemented. This results in several suggested interventions being shared between both local authorities, though the majority are specific to the micro-level context of the relevant Borough. Two concrete Council and school policies are proposed for each identified key barrier to, or driver of, children's physical activity determined through the go-alongs.

Brent: five key barriers to be addressed and associated policy recommendations

1) Pavement Maintenance

- Urgently repair the cracks and pits in pavements, prioritising streets around schools.
- Building on existing online reporting infrastructure, create a 'Pavement Alert', where hotspots of concern in the public space can be reported.

2) Traffic safety and air pollution around school

- Consider permanent prohibitions for non-residents and one-way systems in narrow school streets.
- Enforce measures against antisocial behaviour of adults dropping off or picking up children at school.

3) Greenspace maintenance

- Ensure sufficient staff are employed to maintain greenspace in the Borough, and prioritise children's needs over dogs' in these areas.

- Actively patrol for dog faeces, litter and fly-tipping, and fine perpetrators. Schools could organize 'cleaning-up brigades', sharing the joint responsibility for neighbourhood cleanliness.

4) Centralisation of services and activities
- Maintain local services across the Borough, and not solely in gentrified, central areas.
- Ensure central services can be easily accessed, both physically and financially.

5) Remnants of criminal activity
- Immediately remove remnants of criminal activity. Schools and Borough should then encourage free, outdoor play, emphasising this is not a sign of bad parenting.
- Assist efforts to fight knife crime. Schools can identify a confidential contact person providing information to pupils and allowing them to share experiences and fears.

Brent: four key stimuli to be harnessed and associated policy recommendations

1) Large recreation areas
- Stimulate the post-school use of recreation areas through proper maintenance and the provision of a diverse range of play and exercise opportunities.
- Make these facilities easily accessible by ensuring safe crossings and road obstacles slowing down traffic.

2) Weather-independent play facilities
- Increase the number and capacity of indoor recreation facilities, and swimming pools in particular, making these financially and physically accessible to all children.
- Replicate the success of covered play facilities by providing similar activity opportunities close to places frequently visited by parents.

3) Dead-end streets and home zones
- Introduce traffic barriers to create more cul-de-sacs, and reduce the volume and speed of traffic on secondary roads to allow their use for active commuting and play.

- Expand the number and extent of home zones, especially in the most residential parts of the Borough, to be used for physical activity and leisure purposes.

4) Social cohesion
- Ensure children and adults know each other and get the opportunity to play together by providing supervised neighbourhood sports and play sessions in the outdoors.
- Organize walking school buses and reward children living within one mile from school for walking or cycling, and those living further away for using public transport.

Newham: six key barriers to be addressed and associated policy recommendations

1) Neighbourhood cleanliness
- Increase Council efforts to ensure the public space is kept free of litter and dog or drug waste by employing sufficient staff in charge of neighbourhood cleanliness.
- Actively patrol for dog faeces, litter and fly-tipping, and fine perpetrators. Schools could organize 'cleaning-up brigades', sharing the joint responsibility for neighbourhood cleanliness.

2) Seasonality
- Provide sufficient lighting along busy commuting routes, alleyways and at crossings.
- Increase the number and capacity of well-maintained and accessible indoor leisure centres and swimming pools, and shield outdoor facilities from the elements, to stimulate year-round sports and play.

3) Shared public spaces
- Maintain and diversify public spaces, prioritizing children over cars by reducing car parking space and providing spaces to socialise.
- Remove all 'No Ball Games' signs across the Borough, and contemplate adding 'Children welcome to play here' signs.

4) Remnants of criminal activity

- Immediately remove remnants of antisocial behaviour and crime scarring the built environment.
- Assist efforts to fight knife crime. Schools can identify a confidential contact person providing information to pupils and allowing them to share experiences and fears.

5) Foodscape around school

- Refuse the establishment of new convenience stores and takeaways within a 400m radius around schools. Enforce the display of healthy snacks at counters.
- Schools can offer healthy snacks to their pupils at the end of the school day, which they can consume on the way home instead of energy-dense, unhealthy food items.

6) Airplane noise

- Ensure financial support for school and buildings providing public services, as well as private residences, to be adequately isolated in areas with high noise pollution.
- Carry out independent assessments of airplane noise.

Newham: three key stimuli to be harnessed and associated policy recommendations

1) Physical challenges for children walking

- Implement elements of 'urban parkour' around schools, acting as nudges to stimulate children's enjoyment and activity during the commute.
- Inform pupils and parents of the benefits of active commuting, including strengthening social cohesion and motor skills, instead of focusing on risks.

2) The provision of recreation facilities

- Bring all public and school playgrounds and public recreation grounds up to the standards of the most popular examples across the Borough.
- Properly maintain playgrounds by replacing and updating broken equipment. Provide a diverse set of play elements for children of all ages, and facilitate adult supervision and physical activity.

3) <u>Pedestrian-only alleyways</u>

- Ensure the safety, lighting and cleanliness of alleyways cutting through the Borough, enabling children to use the shortest route to school and other destinations.
- Make sure children feel safe using these pedestrian-only pathways by lowering high walls and trimming disturbing vegetation.

VI. Key takeaways from the qualitative research stage

The abductive thematic analysis of children's expert voices allowed for a unique and compelling insight into the everyday outdoor lifeworlds of young Londoners. The analysis provides an in-depth, context-specific and exceptionally pragmatic response to the qualitative, central research question.

The go-alongs unveiled the importance of resources and rules in shaping children's outdoor energy-expending behaviour, and demonstrated how a multilevel and holistic change of built and social environmental policies could engender a change that is set to be more effective and impactful than the current focus on interventions targeting the individual and the family who have had marginal positive effects at best. Children need to reclaim and be granted their rightful place in the public realm, and the proposed policy suggestions show how their active commuting and extracurricular play and sports engagement can be stimulated through tailor-made strategies that acknowledge the specificities of individual Boroughs and neighbourhoods.

To have any chance of success, the entire set of recommendations needs to be adhered to, and bold steps should be taken by schools and local authorities to finally and firmly address the double epidemic of childhood inactivity and overweight and obesity. The required measures are by no means always big or revolutionary, and the basis for children's healthy, leptogenic environments can already be found in parts of London. These developments could be accelerated by a Borough-wide public health campaign, mitigating a potential further decline in children's daily physical activity, by highlighting the benefits of year-round activity and reducing the risk aversion and sole focus on academic achievements among adults.

An increase in challenging, unstructured outdoor play will benefit all domains of children's wellbeing, far beyond simply the physical: cognitive attention, social affiliation and emotional affect are also bound to be boosted (Burdette & Whitaker 2005). This can shift the dire prospect of half of the population of London schoolchildren facing overweight and associated mental and physical health issues to a future of these children as versatile, engaged adults, relying on their right *"to rest and leisure, to engage in play and recreational activities appropriate to the age of the child"*, as established in Article 31 of the UNCRC (UNICEF UK 2004, p.10).

Chapter 7: The Integrative Stage - Merging Qualitative and Quantitative Evidence

I. Chapter introduction

The spatial epidemiological study of the impact of the built environment on children's extracurricular physical activity and body composition and the micro-scale exploration of their lived experiences of this triad form the prime components of this doctoral research. However, *"integration is really at the heart of the whole mixed-methods enterprise"* (Fielding 2012, p.127). Indeed, it is the active mixing and combination of strengths of both complementary research stages that truly set this work apart from earlier studies in the field. In the explanatory sequential design, the transition from the quantitative to the qualitative stage formed a first *"point of interface"* (Guest 2013, p.146), as the spatial epidemiological results informed the design and sampling strategy adopted in the qualitative study. The integration of both prior stages described in this chapter then constitutes the second, core point of interface, presenting the dialogue between quantitative and qualitative findings. The central research question guiding this process is: *"How do the qualitative findings compare and relate to the quantitative results and help to interpret them?"*

The existing literature on mixed methods describes a wide variety of potential pathways for the merging of results from different research stages and their subsequent, joint interpretation, aimed at providing a holistic answer to this central research question (Bazeley 2012; Creswell 2015; Moseholm & Fetters 2017). As discussed in the methodological chapter (chapter 4), having first collected and analysed the quantitative and qualitative findings separately, I now opt for the triangulation of both sets of results, combining these in search of confirmation, expansion or discordance (Fetters et al. 2013). To the extent possible, data collected via different methods can and should be integrated and interpreted together. It should nonetheless be recognised that contrasting quantitative and qualitative results could also entail diffraction, *"times (and places) where mixed data do not 'fit' together"* (Uprichard & Dawney 2019, p.29). My study produced a complementary set of cartographic-statistical trends and context-specific profiles of the triad linking the built environment to children's physical activity and body composition in London. It is unlikely that the specificities of each of these trends and profiles always fit one, singular narrative. Placing these multiple, complex narratives alongside each other in search of their interconnectedness and divergence thereby allows to more clearly delineate the scientific and political limitations and implications of mono-method research exploring this triad (May 2005).

Regardless of its outcome, the basic rationale for the mixing of findings in this final stage of the explanatory sequential design is to *"dive deeper"* (Plano Clark 2019, p.108), producing insights that go beyond those obtained through mono-method research or the mere comparison of multiple datasets (Vogl 2019). Through the use of multiple and diverse research lenses, this chapter thereby aims to offer a more panoramic view of how the built environment relates to children's primary out-of-school activity components, and how these interactions, in turn, shape their bodies (Shorten & Smith 2017). In addition, the dialogue between the two sets of results contributes to strengthening the validity of the quantitative findings, as well as the credibility of the qualitative observations (Fetters et al. 2013).

Leading scholars in the field of mixed-methods studies have suggested the use of visual aids to foster the comprehensible representation of data and their synthesis. In particular, joint displays are argued to enhance the insights into the obtained findings, as they facilitate the process of plausible and meaningful integration (Guetterman et al. 2015; Johnson et al. 2019; Younas et al. 2020). At the same time, however, such representations also enable the visualisation of the particularities of each individual method, thereby contributing even further to a complete understanding of the subject under study. Hence, joint displays do not only capture the *"more whole"* (Uprichard & Dawney 2019, p.22) outcomes emerging from the mixing of methods – they also comprise and explicate the multifariousness and intricacies of each of their multiple constituent parts.

Accounting for this contextualisation of the role and place of integration in mixed-methods research, this final of three explanatory sequential research stages merges these quantitative and qualitative insights. It does so starting from a joint display, using the human ecological vertex model developed in the conceptual framework as a point of departure (chapter 2). Here, this model is populated with the findings from both prior stages.

As the need to disentangle extracurricular physical activity and body composition was undeniably demonstrated in the quantitative strand of research, I designed two research-specific human ecological models. Each is fitted to represent two different activity and body composition components. The first joint display captures the impact of the habitat, behaviour and population vertices on active commuting, associated with lower fat mass index scores. The second model then has children's participation in extracurricular sports and exercise, significantly correlated with their increased fat-free mass, as its central 'State of Health'. The relevant findings from the quantitative and qualitative stages for these activity and body composition components are then also situated on the three model vertices. Both visual displays are accompanied by a narrative discussion. The chapter is completed by a summary of key takeaways from the mixing of findings and ensuing policy recommendations.

II. Integrating qualitative and quantitative findings in the ecological framework

a. The human ecological model for active commuting and FMI

Figure 15 presents the joint display bringing together the quantitative and qualitative findings on the human ecology of children's active commuting in London, associated with lower adiposity levels, arising from my research. Using a colour scheme, this visual representation highlights areas where findings from both stages corroborate, contest or complement each other. The statistical analyses highlighted the importance of breaking down the environment-activity-body composition triad into its constituent steps. Therefore, first, the confirmation, discordance or expansion of results from both prior stages is discussed for the link between children's built environments and their choice of a specific mode of commuting to school. This relation is then framed within the wider habitat, population and behavioural human ecological model vertices. Secondly, the human ecology of the relation between commuting and body shape is then explored, mixing the sequentially obtained findings.

Population

Quantitative	Qualitative	Quantitative	Qualitative
Age & Gender		**Genetics, body shape & personal development**	
Older children significantly more likely to actively commute	**Children in final years** granted more freedom to walk or cycle to school	**Black children** had about half the odds to actively travel to school	**No clear ethnic differences** emerged
No sex difference observed	More concerns voiced for **girls**	**Obese children** less likely to walk or cycle	**Children with fuller body shapes** voiced a preference for passive commuting
			Active commuters found to have better gross motor skills and spatial awareness

The State of Health
Active commuting to school, inversely associated with FMI

Habitat

Quantitative	Qualitative
Built	
Objective **proximity** key correlate of increased active commuting	Perceived **proximity** to school seen as prime stimulus for walking or cycling
Extremes of **traffic risk** consistently associated with lower levels of active travel	**Traffic safety** concerns at specific points along route deter active travel
Personal risk extremes only individually associated with less walking and cycling	Remnants of **crime and antisocial behaviour** reduce active commuting
Peaks of **air pollution** linked to lower active commuting, though only in individual models	Children aware of **pollution** and dense traffic, though often unavoidable
Walkability only individually associated with increased active school commuting levels	Road crossings, pavement maintenance and social aspect key to child **walkability**
Denser **foodscape** comprehensively associated with more walking and cycling	Children at times stopped at **food outlets**, though not decisive factor in commuting decisions
Social	
Higher **family affluence** resulted in lower odds of active school commuting	
Natural	
	Importance of **weather and seasonality**
	More-than-human **natural environment** stimulates enjoyment of commute

Behaviour

Quantitative	Qualitative
Social organisation	
Proximity of schools to children's homes incites walking and cycling	**School admission policies** for local children crucial
Traffic safety of road environments associated with more active travel	**Road maintenance** policies key to safe active commuting
	School restrictions on independent commuting to school with age
	Park & Stride policies incite walking
Beliefs	
	Parental active commuting acts as role model for children
	Social pressure against independent commuting
Technology	
Car ownership reduces active school commuting	**Cars** in the household, especially for mothers, incite passive transport
	Mechanical issues with bikes limiting factor
	Mobile technologies create in(ter)dependent commuting opportunities

Legend	
	Confirmation
	Expansion
	Discordance

Figure 15: Human ecological triangle for active commuting to school and FMI

i. Step 1 - The relation between the built environment and commuting in the human ecological triangle

The six predefined built environmental characteristics retained from the literature review form the core of the habitat vertex in the human ecological model. Starting the integrative analysis at this vertex, the positive effect of proximity to school stands out both from a quantitative and qualitative perspective. Irrespective of individual or socioeconomic characteristics, children living closer to school were more likely to walk or cycle during their daily commute. The statistics and GPS data demonstrated that this effect was significant for participants residing within 1.5km from school along the route network, and became stronger as children lived closer. The walk-alongs then highlighted that time constraints are the primary reason those living further away opted for car- or public transport-based travel.

There are, however, instances where this straightforward, inverse relation between distance and active travel could not be observed, as other habitat, population or behaviour vertex components outweighed the stimulus for active commuting provided by physical proximity. Perception is a main driver of objectively counterintuitive commuting decisions. Subjective experiences of travel time, road and personal safety, and practical concerns such as weather conditions were all invoked to justify a choice of passive modes of travel. Social and natural environments, as well as beliefs, thus overruled the proximity effect in those instances, even if the distance to school was objectively within walkable or bikeable limits.

Car ownership, especially by both parents and mothers in particular, also resulted in a higher likelihood of shorter commutes being completed using private, motorised transport. In contrast, families without access to a car often underlined that the choice of walking or cycling was self-evident, even for distances beyond the 1.5km mark. The spatial epidemiology found further differences along socioeconomic and ethnic lines, which the qualitative stage could substantiate. Statistical modelling showed that children from affluent families were less likely to actively commute to school, often closely intertwined with their higher car ownership. During the go-alongs, this decision to passively commute was legitimated by the tight activity schedules children were subjected to, as well as caretakers' own time constraints. The quantitative data also highlighted that black children were less likely to walk or cycle to school. While this association was observed independent of school proximity, the fact children of African ancestry had longer average commuting distances amplifies this inequality, raising questions about school admission policies and residential segregation. The interviews and activity diaries highlighted this residential remoteness drove their reliance on passive, and primarily public, transport to school.

The quantitative and qualitative findings are also in accordance with regard to the second predefined built environmental characteristic, traffic risk. Car-dominated urban environments with high accident levels significantly reduce the likelihood that children opt for active modes of transport to school. The interviews provided powerful insights into the materialised anxiety unsafe traffic experiences instilled in participants and their caretakers in London. Speeding cars ignoring traffic lights and zebra crossings and vehicles parked on pavements deterred children from opting for walking or cycling. The fear these high-risk events inspired also was a main reason for commuters to not adhere to the distance-based logic described above. Their consequential use of motorised transport thereby contributed to increasing the traffic risk for remaining pedestrians and cyclists.

The statistical models revealed that extremes of risk *en route* to school acted as particularly strong deterrents for active commuting. In analogy, during the go-alongs, interviewees pointed out specific places along the commuting route that constituted hotspots of unsafety and concern. Busy crossroads posed particularly grave obstacles. Similarly, the direct school environment was a spatiality where participants experienced strong anxiety. Parents rushing to drop off or pick up their offspring, hampering active commuters in the process, created distinctly unsafe road conditions. Most interviewed pupils who commuted actively took great care when negotiating these complex traffic situations. From a behavioural perspective, however, older children were granted more freedom to confront these risks independently, as parents or caretakers considered them more capable of doing so in the later years of primary school.

The second risk-based habitat vertex component, personal safety, only showed significant associations in the pairwise, confounder-controlled multilevel models. There, children confronted with higher extreme crime rates along the route to school were found to be less likely to actively travel to school. The lack of significance in the comprehensive statistical analyses points to the predominance of other environmental model components in determining commuting outcomes. The go-alongs provided a qualitative understanding of these quantitative findings. Indeed, the interviews showed that, while a large number of children crossed urban environments with elevated crime rates during their daily active commute, they rarely did so independently. Permanent parental supervision and accompaniment allayed these fears of stranger danger. Nonetheless, even though other objective built environmental elements appear to be more dominant in steering commuting decisions, children's confrontation with remnants of crime and antisocial behaviour – such as graffiti, burnt out cars or syringes – inspired a real sense of fear of the 'unknown other'. A close-knit community and a strong sense of social cohesion were argued to be crucial to increase the perception of safety, making children, and girls in particular, feel more at ease when commuting. From a built environmental perspective, the go-alongs also added the aspect of lighting to the equation, as children felt safer commuting along otherwise dark routes if ample street lighting was provided in autumn and winter.

Similar to the statistical findings for personal risk, peaks of air pollution were only individually associated with a lower likelihood of SLIC children walking or cycling to school. The acute risk of traffic accidents thus appears to predominate over longer-term health risks associated with air pollution when making commuting decisions. A large share of participants was therefore confronted with high concentrations of airborne pollutants during their daily commute. The qualitative data were in agreement with these findings. Parents driving their children to school by car contributed to creating pollution hotspots around the school gate, as they queued – engines idling – to drop off or collect their offspring. The go-alongs also pointed to other forms of pollution hindering active commuting, often found in public spaces where the air quality was higher. Dog faeces, loud noises and fly-tipping were frequently raised as habitat elements lowering the enjoyment of the walk or cycle to and from school.

Discordance emerges for the fifth predefined built environmental characteristic included as part of the habitat vertex in the human ecological model: walkability. The combination of residential density, street connectivity and land use mix showed significant associations with a higher likelihood of London primary schoolchildren to actively commute to school in the spatial epidemiological analyses. However, these associations were only found in the binary and individual multilevel statistical models, once again underlining the predominance of the impact of proximity and traffic safety. The qualitative results add to these findings by highlighting that several Walkability Index components were found to have opposite effects on children compared to adults. Firstly, contrary to what was hypothesised, a dense street network with a high number of junctions to be crossed impeded children's walking and cycling, as these posed major obstacles for participants. Moreover, positive features of walkability such as residential density and land use mix tended to provide interviewed pupils with a sense of safety due to the presence of people on the streets, inciting them to walk or cycle. This effect rapidly disappeared, however, once a critical density threshold was reached. The presence of larger volumes of unknown individuals on pavements, or groups of people obscuring their view and sense of direction, scared children, making crowded urban environments less walkable or bikeable. The go-along interviews were thus able to uncover the limitations of current walkability metrics. In addition, they also expand the knowledge on walk- and bikeability by suggesting new components, critical to ensuring a satisfactory streetscape for children. Central to these streetscapes are the provision and maintenance of adequate walking and cycling infrastructure, separated from roads themselves. The overreliance on motorised transport in urban environments has pushed walking and cycling away from the street. Pavements, spatialities of close interaction between children's bodies and their human and more-than-human surroundings, emerge as the core urban spaces to which commuting is restricted today. The poor state of London pavements raised by interviewees thereby poses a further threat to active school travel.

The quantitative and qualitative stages result in complementary findings for the density of convenience stores along the route to school, the final built environmental variable included based on by the literature review. The spatial epidemiology showed that high densities of these unhealthy food outlets, typically found closer to the centre of London, were comprehensively and significantly associated with higher levels of active commuting. The micro-level insights from the qualitative research component indicated that this relation between the foodscape and commuting works in an indirect manner. None of the children referred to the presence of convenience stores as a decisive factor in the choice to walk or cycle to or from school. This makes it likely that the statistical association between both is due to the strategic location of convenience stores in places with high footfall. Indeed, the go-alongs did reveal that children and their accompanying adult regularly stopped at convenience stores or fast food outlets on the way home after school, purchasing primarily energy-dense snacks and drinks. These visits were facilitated by the dense, unhealthy foodscapes surrounding major commuting routes.

Irrespective of individual and family characteristics, urban built environments with schools within walking distance, sufficient and well-maintained pavements, safe crossroads, reduced motorised traffic in the direct school surroundings and ample lighting along routes are thus likely to incite children to opt for active modes of travel. These characteristics have to go hand in hand with the prompt removal of remnants of crime and antisocial behaviour, litter and dog faeces, and the stimulation of visible, cohesive social networks in school neighbourhoods, allaying children's fears and anxieties and fostering in(ter)dependent commuting. Routes that meet these conditions, which I have evidenced to be minimum requirements, form the foundation of walkable and activity-inciting commuting trajectories.

Moving beyond the six predefined habitat vertex components and the population and behavioural factors that influence their observed dynamics, the qualitative stage revealed additional human ecological elements that were not theorised, yet should be accounted for. First, part of the habitat vertex, children thoroughly enjoyed a beautified, diverse and well-maintained natural environment along the route to school, with trees and flowers stimulating their imagination and being attributed human traits.

Next, two elements of expansion stand out from a social organisational perspective, belonging to the behaviour vertex. Firstly, school and Borough policies restrict active commuting, for instance by barring independent commuting until Year 5. Other policies hold the potential to foster walking, but lacked vigorous implementation, for example Park & Stride opportunities. While activity-inciting policies are thus essential to stimulate active school travel, the existing restrictive regulations nurture fear among children and their caretakers, creating risk-averse helicopter parenting. Secondly, priority given to local children in school admission amplifies the positive effect of proximity, as pupils are more likely to walk or cycle to a nearby school. Moreover, this generates a critical density of actively commuting children and greater social cohesion. Together, these contribute to the establishment of a self-sustaining, positive feedback loop driving increased physical activity. With regard to technology, the interviews demonstrated that mobile technologies such as smartphones play an important role in reducing parental fears about their child's safety when travelling to school. These forms of interdependent commuting explain in part the finding of increased active commuting with age. In contrast, basic mechanical issues like broken-down bicycles limit activity opportunities, which are mitigated through support provided by schools, for instance via bike doctor clinics.

When discussing these aspects of the behaviour vertex, children tended to describe their close, (more-than-)human and emotive personal experiences with its components, influencing their perceptions and actions. An argument could therefore be made to rethink this as an 'experiential human ecological vertex'. This would open up a new field of future research into children's context-specific encounters with elements of social organisation, beliefs, and technology, and the role of these often intense experiences in deepening our understanding of the observed behavioural outcomes.

Finally, active commuters in the go-alongs consistently displayed greater spatial awareness in comparison to their passively commuting peers. This trait, part of the population vertex, advances their rapid personal development.

ii. Step 2 - The relation between commuting and body composition in the human ecological triangle

The statistical analyses highlighted the importance of disaggregating total body weight into its fat and fat-free components. Children who actively commuted to school were found to have lower odds of being overweight or obese, while their muscle development did not significantly differ from passive commuters. During the qualitative data collection, I therefore set out to uncover context-specific, human ecological factors that stimulate children's engagement in walking and cycling to school, acting as a key pathway to stem the childhood obesity epidemic in London.

While body shape did not constitute a primary focus of the qualitative research strand, during the go-alongs, children and accompanying adults regularly made reference to commuting as a contributor to weight maintenance or loss. Moreover, those having excess weight tended to acknowledge their body shape by identifying as 'obese' or 'heavy'. Their narratives, accelerometry and activity diary data thereby produced insightful additional information helping to fully grasp the quantitative trends. This information is included in the reflections on the human ecology of the relation between active commuting and children's body composition. The statistical models, however, not only found that active commuting was inversely associated with the likelihood of belonging to the overweight or obese fat mass categories, but also that children with FMIs in the obese category were less likely to actively commute to school than those without excess fat mass. Similarly, during the go-alongs, interviewees with fuller body shapes frequently indicated experiencing physical discomfort when walking or cycling to school, entailing a preference for passive commuting. The bidirectionality of this relation points to the existence of a vicious obesogenic cycle in which passive commuters and children with excess fat mass could get trapped.

The accelerometry highlighted that physical activity around school end times offered a tremendous opportunity for children to collect their daily required amount of MVPA. The go-alongs showed that the after-school commute could entail higher levels of energy consumption, as children sprinted, jumped, climbed stairs, used gym equipment in parks or purposely chose detours on the way home. The qualitative findings also unambiguously demonstrated that the overwhelming majority of children intrinsically preferred active commuting over passively travelling to school, in contrast to their parents or caretakers. Walking or cycling, especially when done independently of adults but accompanied by siblings or peers, grants children an unprecedented sense of freedom and an opportunity to experience autonomy, build and negotiate social networks, strengthen their gross motor skills, and further develop their spatial awareness. This, once again, highlights the importance of physical activity, not only for the physical health of London's youngest citizens, but also for their mental and social wellbeing.

While no sex differences were found in the statistical models, the go-alongs indicated that this freedom was more easily awarded to boys, contrasting with the safety concerns and obstacles voiced in relation to girls' mobility. The organisation of the commute itself was also highly gendered, with mothers carrying the main responsibility for ensuring that their offspring reached school each day. However, several parents, acting as positive role models, indicated that they enjoyed their walk or cycle to school while being able to work out, maintain or lose weight, and bond with their children. A more widespread adoption of this attitude among groups who are prone to commuting passively – in particular children identifying as black and those from highly affluent families – can drive the uptake of active modes of travel, contributing to the simultaneous tackling of childhood and adult overweight and obesity.

b. The human ecological model for extracurricular sports and exercise and FFMI

The second pathway linking the built environment to children's weight status following the disentanglement of physical activity and body composition components runs via out-of-school sports and exercise. In contrast to the findings for active commuting, the spatial epidemiology showed no significant correlation between this form of extracurricular physical activity and SLIC children's fat mass. However, the statistical models revealed that participants' more frequent engagement in extracurricular sports and exercise was significantly associated with their higher likelihood of having a strongly developed fat-free mass. As muscle mass is the prime component of this fat-free mass, participation in sports and exercise thereby emerges as the pivot mediating the relation between the children's environments and their muscle accretion.

Hence, *figure 16* visualises the integrated human ecological model for this activity component and FFMI by jointly displaying the quantitative and qualitative findings for these variables. In analogy to the approach taken for active commuting and FMI, the built environment-activity-body composition triad is again broken down into its constituent two-step chain for the discussion of this second model. Firstly, the findings on the effects of the built environment on children's participation in sports and exercise arising from the first two stages of the explanatory sequential mixed-methods research are synthesised. These are then framed in the wider set of human ecological model components belonging the habitat, behavioural and population vertices. Secondly, both sets of findings are then integrated in order to explore the link between this form of extracurricular physical activity and body shape, in search of confirmation, expansion or discordance.

Population

Quantitative	Qualitative	Quantitative	Qualitative
Age & Gender		**Genetics, body shape & personal development**	
Older children significantly more likely to frequently participate in sports	**Children in final years** granted more freedom to engage in outdoor activity	Accelerometry shows higher activity for **black** pupils, though no statistical effect	No diverging narratives according to **ethnicity**
No **sex difference** observed in statistics, boys more active in accelerometry	More concerns voiced for **girls, boys** indicate to prefer more team sports	Children active less-than-weekly show lower **fat-free masses**	Varying narratives on activity engagement found for children of all **body shapes**
			Active children found to have better gross motor skills and spatial awareness

The State of Health
Extracurricular sports engagement, positively associated with FFMI

Habitat

Quantitative	Qualitative
Built	
No relation between **proximity** to facilities and frequency of sports and exercise	**Perceived proximity** to high-quality greenspace inciting outdoor activity
No significant association between **traffic risk** and sports and exercise	Recreation set away from roads, hence **traffic safety** of route to facilities relevant
No objective **personal risk**-extracurricular sports and exercise relation	Remnants of **crime and antisocial behaviour** and fear of the unknown other reduce out-of-school recreation
No quantitative links between **air pollution** and out-of-school sports and exercise	**Pollution** from litter, noise and animals (dogs) experienced as problematic
Walkability unrelated to children's frequency of sports and exercise participation	Lack of **walkable and bikeable** routes to facilities hampered outdoor activity
Foodscape not linked with extracurricular sports and exercise	Unhealthy **food outlets** incite exercise to facilitate sedentary activities
	A wide **diversity of well-maintained facilities** attracts outdoor activity
Social	
No significant effect for **socioeconomic status** in relation to outdoor recreation	**Less well-off families** describe lower potential to afford organised activity
	Siblings/peers drive activity
Natural	
	Importance of **weather, climate and seasonality**, particularly darkness
	Fear and appreciation of dogs and other **animals**

Behaviour

Quantitative	Qualitative
Social organisation	
Accelerometry shows limited share of children **meets** WHO activity **thresholds**	Focus on **intellectual development** limits children's free time for outdoor activity
Accelerometry highlights importance of **in-school physical activity**	**Schools** described as core **activity providers**
Accelerometers show significant drop in physical activity on the **weekend**	
	Cohesive **social network** stimulates outdoor sports and recreation
	Admission to local school crucial to be acquainted with neighbourhood
	Centralisation of local services reduces recreation opportunities
	Park & Stride policies incite free, outdoor sports and play
Beliefs	
	Parental active lifestyle acts as role model for children
	Fears and risk-averse society causes low outdoor activity engagement
Technology	
	Excessive **screen time and sedentary activities** limit time spent outdoors
	Technology as a means of **supervision** raises outdoor activity levels
	Mechanical issues with bikes limiting factor

Legend	
	Confirmation
	Expansion
	Discordance

Figure 16: Human ecological triangle for participation in extracurricular sports and exercise and FFMI

i. Step 1 - The relation between the built environment and extracurricular sports and exercise in the human ecological triangle

Starting by integrating the findings for the six predefined built environmental characteristics included in the habitat vertex in relation to children's extracurricular sports and exercise engagement, the absence of significance in the statistical models, relying on a self-reported activity variable, contrasts with the expansive evidence obtained through the qualitative .

The multilevel models did not reveal a clear link between the frequency with which children headed out to play and do sports outside of school hours and their proximity to their nearest park, public garden or sports facility. The qualitative research offered a plausible rationale for this lack of objective associations. While participating children voiced a strong desire to engage in extracurricular physical activity using facilities close to the home, in particular areas of greenspace, these facilities had to meet a well-defined set of conditions in order to be appealing. Greenspace required proper upkeep, and equipment needed to be challenging, diverse, well-maintained and provided free of charge. These observations tie in closely with the second habitat component, the natural environment. As mentioned above, parents were scared of their offspring falling ill in the rain and cold, and children feared playing outside in the shorter, dark autumn and winter days. Facilities were therefore found to be particularly popular if they were sheltered from the elements by a roof, emphasising the attraction of diverse, weather-independent facilities, both indoors and outdoors, to stimulate children's out-of-school physical activity in London.

As this set of strict prerequisites was rarely met by the nearest park, public garden or sports and recreation facility, interviewees tended to prefer using elements of the public space situated further from their homes, thereby defeating a purely proximity-based logic. Simply providing a patch of grass close to residential areas was thus insufficient to make children want to come outside and engage in physical activity, especially as such places were often littered with rubbish and dog faeces. In contrast, the go-alongs highlighted the tremendous potential of activity-inciting, diverse greenspaces with well-maintained sports and play facilities close to school, such as Northwick Park in Brent. Situated within a two-minute walk from the school gate and adjacent to a Park & Stride facility, participants often preferred this area for after-school play over the recreation opportunities in their direct home environment, especially given the presence of peers.

Secondly, the qualitative stage also proved key to clarifying the lack of statistically significant associations between objective rates of road accident in the home neighbourhood and children's engagement in sports and exercise. Parental and child perceptions of, and ensuing concerns about, traffic risk result in outdoor recreation being restricted to spatialities where there is little to no traffic. As a consequence, children use clearly delineated areas of greenspace, recreation facilities, alleywa 265 l-de-sacs for sports and play, separated from roads with motorised transport. Children and caretakers indicated that they did not feel comfortable with the idea of participating in outdoor exercise on streets or pavements, even in the most residential (sub)urban areas, thereby removing any potential effect of objective levels of road safety. From a behavioural vertex perspective, these decisions were driven by the belief that allowing such activity would be irresponsible, a notion perpetuated by local media and school and Borough activity policies. Illustrative of this trend is the observation that even running and cycling, traditionally done along neighbourhood streets, was increasingly limited to the safe boundaries of parks or public gardens.

Closely related to these findings for traffic safety, the statistical associations for air pollution did not reach the significance threshold either. The qualitative evidence underlined that, as outdoor sports and exercise were set at a distance from traffic-dense environments, there was also lower direct exposure to high concentrations of airborne toxins emanating from vehicles in these areas. Nonetheless, the go-alongs demonstrated that dog faeces and litter are more prominent and activity-deterring forms of pollution in parks, public gardens and recreation facilities.

In analogy, the fourth predefined built environmental variable belonging to the habitat vertex – the combination of residential density, street connectivity and land use mix making up the Walkability Index for London – was not quantitatively associated with extracurricular sports and exercise. The go-along interviews highlighted that this was also due to this activity being restricted to spaces separated from the road network. Nonetheless, the qualitative findings suggested that walkability can still have an indirect effect in determining schoolchildren's recreational physical activity engagement, as these designated sports and play areas need to be physically accessed. Therefore, places where sound urban planning ensures a dense land use mix with ample greenspace close to children's homes and schools, along calm and safe routes, are critical to guarantee they have the opportunity to gather sufficient extracurricular sports and exercise.

Fifth, a clear contradiction emerges between the absence of a statistically significant link between crime rates and children's out-of-school recreational physical activity, and the strong qualitative evidence on the relation between perceived personal risk and participants' restricted activity levels. Subjective safety concerns held by citizens thus appear to outweigh objective crime statistics when making decisions relating to their extracurricular sports and exercise engagement. This materialised fear of antisocial behaviour is embodied by remnants of criminal activity, aggressive dogs and rude dog owners, drunk strangers, and groups of adolescents. Moreover, highly mediatised, anxiety-inspiring threats of knife crime and abduction were elaborately discussed by participants, and emerged as the primary reason not to engage in unsupervised outdoor sports and exercise. The presence of peers, caretakers and volunteers running supervised physical activity sessions in the outdoors had the opposite effect. However, no arrangement proved as popular as indoor sports and exercise, where both the social desire for permanent supervision as well as the control of weather and climate are satisfied. The swimming pool is a textbook example of such suitable activity space.

The density of convenience stores in the home neighbourhood, the sixth and final predefined habitat characteristic, did not show a significant statistical association with children's frequency of sports and exercise participation in the multilevel models either. Nonetheless, the qualitative research stage pointed to the paradoxical role played by these food outlets as a stimulus of walking or cycling in order to facilitate sedentary activities. Interviewees and their caretakers recounted running to convenience stores for snacks, for instance when planning on watching a film, gathering additional minutes of physical activity in the process. Moreover, the growing provision of facilities for active recreation in shopping malls and commercial areas could be noted, such as the London Designer Outlet in Wembley. These facilities increasingly incite children to perform their physical activity in food-dense surroundings during weekends, creating an effect similar to the presence of ice cream vans and food trucks around parks and playgrounds. This encourages the casual consumption of highly calorific foodstuffs.

The joint findings for the built environment thereby reveal that, with the exception of car-free alleyways and cul-de-sacs, the road environment is no longer the domain of children's free, outdoor play, sports or exercise. Children are ruled out of these 'old-fashioned' physical activity surroundings, and pushed back to clearly demarcated, often fenced areas of greenspace and recreation facilities. Frequently, they are limited entirely to indoor spaces, primarily swimming pools, in a supervised environment where poor weather conditions or colder seasons don't pose an imagined threat to child health. The physical separation of the direct road environment around children's homes and schools from the places where they engage in extracurricular active recreation thus results in the absence of an objective relation with built neighbourhood characteristics. The key pull-factor to the outdoor space for sports, exercise and play is the provision of easily accessible, well-maintained, diverse and challenging natural or man-made amenities.

Beyond a focus on the six predefined built environmental variables, the context-specific exploration of participants' lifeworlds in the qualitative stage revealed a set of additional, influential human ecological factors not included in the spatial epidemiological study.

While the built environmental component of the habitat vertex has been discussed at length, elements of the natural environment, belonging to the same vertex, also impacted children's activity decisions. Outdoor public spaces were found to be more attractive when they contained natural features such as ponds or small forested patches, also presenting physical challenges. This allowed children to interact closely with plants and animals that are a source of fascination and imagination. However, the majority of children indicated that they were scared by the presence of dogs and annoyed at their waste, and preferred that they were kept at a safe distance.

Studying the third and final habitat vertex component, the socioeconomic environment, the qualitative research revealed that activity opportunities were more accessible if these were made available free of charge. Fees, particularly for indoor sports and play facilities, rule out their use by families of lower socioeconomic status, as was illustrated during the go-alongs. Children from more affluent families could afford to partake in activities against a fee, whereas those from less affluent families mainly engaged in free sports and exercise. This difference in the set of activities children engage in based on the financial position of their families could explain the statistical null-findings showing no significant difference in children's sports and exercise frequency with affluence.

The combination of methods in the second research stage also provided a host of novel insights into components of the behaviour vertex, largely absent from the quantitative analyses. Once more, these related closely to children's own lived experiences, supporting the argument to rethink the behaviour vertex as an experiential vertex. From a social organisational perspective, the accelerometry showed that schools do not function purely as a primary education provider. The observation that interviewees gathered over half of their daily minutes of MVPA during school hours pointed to their additional role as key activity provider. The accelerometry revealed a particularly dramatic drop in the duration and intensity of children's physical activity on Saturdays and Sundays. This demonstrates the tremendous lack of healthy extracurricular activity routines, especially on the weekend, vital in the fight against the inactivity epidemic.

Furthermore, aside from active role models and cohesive social networks of peers, siblings, family members and neighbours, school and Borough policies are vital drivers in the push for an increase in extracurricular physical activity. Schools admitting a large share of children from their immediate neighbourhoods strengthen local community networks. Moreover, the qualitative research highlighted that the implementation and enforcement of Park & Stride policies, in collaboration with Borough Councils, is able to stimulate after-school play. However, both school and Councils mainly tend to throw up hurdles to higher levels of out-of-school sports and recreation. An excessive focus on intellectual development by schools, exacerbated by the vast volumes of homework and after-school or weekend classes for participants, rule out attention to children's physical and social development. Similarly, Borough Councils tend to facilitate car-based travel at the expense of children's activity, for instance by installing 'No Ball Game' signs on squares. In addition, the centralisation of services in gentrified urban centres further removes the opportunities for their youngest citizens to be active by limiting the variety of possible destinations for recreation.

Aspects of technology play a similar, dual role. While mobile technologies and outdoor toys draw children to the outdoors for in(ter)dependent recreation, all too often, screens, game consoles and other forms of indoor technology act as shackles, confining children to sedentary activities.

Finally, a first element of the population vertex can also be raised here in relation to children's personal development. As was observed for actively commuting children, those who headed outside more frequently to engage in sports and exercise showed greater spatial awareness during the interviews, and appeared to have more strongly developed gross motor skills.

ii. Step 2 - The relation between extracurricular sports and exercise and body composition in the human ecological triangle

The exploration of the link between children's participation in extracurricular sports and exercise and their weight status, the second of two steps in this chain, once again highlighted the critical importance of disentangling the core components of total body mass. While children who were active less than once a week were less likely to fall in the overweight or obese BMI categories, the multilevel models showed that this was primarily due to their significantly lower fat-free masses. Daily physical activity was thus associated with greater muscle accretion, raising total body mass and entailing the potential misclassification of sporty children as overweight or obese based on their BMI score. In contrast, whilst not reaching the significance threshold, completely inactive children showed a trend towards belonging to higher FMI categories, thereby being correctly classified as having excess unhealthy weight.

These statistical observations with regard to body shape, belonging primarily to the population vertex of the human ecological model, were supported by the go-along interviews, accelerometry and activity diaries. Several children with fuller body shapes were found to frequently participate in out-of-school sports such as rugby, swimming or martial arts. In contrast, other children labelled as 'heavy' or 'obese' by their caretakers described their discomfort when engaging in extracurricular physical activity. This further reduced their activity frequency and contributed to creating a vicious cycle of weight gain and increased time spent in sedentary condition.

Age, sex and ethnicity also play a decisive role in determining children's sports and exercise outcomes, thereby influencing their body composition. Strengthening the statistical findings, the go-alongs illustrated that older children were granted more freedom to be independently active outdoors, often tied to their perception as more mature by caretakers. While multilevel models did not show significant differences between the sexes, the interviews revealed that boys mainly enjoyed taking part in team sports or adventurous activities with peers, whereas girls showed a preference for more sedentary outdoor group activities. The statistical associations for self-reported ethnicity did not reach the significance threshold, though the accelerometry showed higher overall activity levels for black children. This is in accordance with the quantitative findings that children belonging to this ethnic group also had the highest FFMI levels. However, no differences could be noted concerning the narratives on participation in outdoor sports and exercise among children and caretakers who identified as belonging to different ethnic groups. It is well-documented that the overwhelming majority of minority ethnic primary schoolchildren are confronted with incidents of discriminatory behaviour, and that children have a basic understanding of what constitutes discrimination already at Reception age (Brown & Bigler 2005). The absence of concrete references to ethnicity from children's narratives when discussing participation in physical activity is therefore particularly interesting. Children did not explicitly identify ethnic discrimination as a driver of negative physical activity experiences or reduced access to activity opportunities, and any instances of discrimination did not percolate their narratives on the built environment, commuting and sports and play. This presents an argument for an open discussion about racism with primary schoolchildren, so they are equipped with the necessary tools to identify, acknowledge and address instances of discrimination based on ethnicity.

Completing the human ecology of this second step, higher family affluence and the receipt of free school lunches both showed statistically significant associations with higher muscle mass accretion, though children belonging to the latter group also had significantly higher FMI scores. Analysing this socioeconomic habitat vertex component qualitatively underlined that children from less affluent families had fewer opportunities to engage in the wide range of outdoor and indoor activities year-round, as they were often required to pay an entrance or joining fee. Maximising the frequency of sports and play engagement thus remains the privilege of the happy few who can afford it.

III. Key takeaways from the integration of findings

Confirmation, expansion, and discordance. Integrating the quantitative and qualitative findings from the explanatory sequential mixed-methods study delivered on its promise. While the spatial epidemiology proved highly successful in revealing London-wide physical activity and body composition trends for primary schoolchildren, the associations could only be fully understood via the collection of local, context-specific evidence on children's lived urban experiences. Conversely, the compelling narratives of interviewees and their caretakers alone could not be upscaled without quantitative backing of their potential impact on tackling the childhood inactivity and obesity epidemics. However, it was not until the performance of a holistic synthesis of these two strands of research that a 'more whole' understanding of children's disentangled out-of-school physical activity and body composition in their built environments could be gained.

The human ecological models developed for children's physical inactivity and overweight and obesity in the conceptual framework (chapter 2) proved particularly suitable to facilitate the integration of quantitative and qualitative findings on these states of health. The visualisation and synthesis of outcomes of my explanatory sequential mixed-methods research in a joint display provided a rationale for the observed direct statistical associations between children's route environments, mode of commuting to school, and reduced fat mass. Proximity and traffic risk stood out from a spatial epidemiological perspective. However, the go-alongs illustrated the importance of perception, behavioural beliefs, policy and technology in influencing these choices, at times throwing a spanner in the works of the dominant, objective distance- or risk-based logic.

Similarly, the go-along interviews not only provided an explanation for the absence of statistical associations between predefined built habitat characteristics and children's participation in sports and exercise and muscle accretion. They also allowed an unprecedented insight into activity stimuli and barriers at play. With this form of extracurricular activity being set at a safe distance from the road environment, the provision and maintenance of a diverse, universally accessible set of recreation facilities and greenspace is crucial to stimulate children's healthy body composition development. The qualitative stage also pointed out that a more precise quantification of these built environmental characteristics might have yielded a larger number of statistically significant results, underlining the importance of meaningful variable specification.

The outcomes of this synthesis in the final stage of the mixed-methods research design demonstrated the skewed or incomplete image that would have emerged if only one of the two prior stages had been adhered to. This calls into question the validity of solely quantitative or qualitative studies, and the extent to which these could actually contribute to turning the tide on childhood inactivity and obesity. Moreover, my findings can also be used to develop unique policy pathways to simultaneously tackle both epidemics in London. The human ecology and ensuing impacts on body composition of the two core extracurricular physical activity components showed important differences. Hence, appropriate policies tailored to fit each activity component need to be developed. As place does matter, these policies are required to address the varying, context-specific built environmental factors that hamper, or facilitate, children's active commuting and sports and play engagement with equal sensitivity.

The integrated findings with regard to active commuting can be categorised into a set of four key policy recommendations to be implemented in London, shifting attention from blaming individuals and families to the urgently needed structural changes to children's built environments. These recommendations hold the potential to increase the share of children opting to walk or cycle to and from school upon implementation:

- Urban planners should take the minimum requirements for the characteristics of objectively safe and walkable routes to school into account, paying particular attention to traffic-free or calm roads, road crossings, well-maintained pavements, and the provision of sufficient lighting.

- School and Borough policies should provide a framework encouraging and rewarding active school travel for children and parents. Traffic restrictions in school streets, Park & Stride policies, allowing independent commuting from younger ages, and walking school buses are all examples of such measures, and need to be promoted, monitored and enforced.
- Ensuring strong social cohesion will be vital to generate a critical mass of active commuters, simultaneously allaying fears for children's personal safety and changing the risk-averse narrative surrounding active commuting.
- Elements adding to the enjoyment of the commute could act as further pull-factors or nudges for walking or cycling. The beautification of routes to school with natural elements is particularly powerful in that regard.

In order to raise the frequency with which children engage in extracurricular sports and exercise in London, three main areas for policy and interventions could be delineated:

- Councils should provide well-maintained and diverse areas of greenspace and recreation facilities, both in- and outdoors. Local swimming pools and covered playgrounds hold particularly great potential to raise children's activity levels. These facilities stimulate year-round physical activity, and should be distributed equally across the public space, avoiding excessive centralisation.
- The routes to these local facilities should meet the minimum requirements described for active commuting. This physical accessibility further incites the collection of physical activity as children will be able to reach these neighbourhood destinations using active means of transport.
- Opportunities for sports, exercise and play outside of school hours should also be available to all, both socially and economically. This socioeconomic accessibility should be supported by integrative social structures and policies fostering inclusivity and equal opportunities, for instance by waiving the access fee to swimming pools permanently for children from family with low affluence.

My research does not only provide an unprecedented pathway to tackle children's inactivity and excess weight in London. This explanatory sequential mixed-methods design and its outcomes also constitute an impetus for other urban environments in the UK and Europe confronted with similar pressing issues to tackle both epidemics boldly and seriously. The integration of findings constitutes a methodological and policy-related template to be replicated in these other contexts.

Chapter 8: Conclusion – Having Connected Children's Built Environments, Extracurricular Physical Activity and Body Composition

Today, over 330 million young citizens around the world between the ages of five and nineteen are confronted with overweight or obesity. This figure represents a tenfold increase in the number of children and adolescents with excess weight over the course of the past four decades. Worryingly, the deepening of this global epidemic shows no sign of slowing. Faced with this severe public health crisis and the heavy financial burden it entails, researchers and policymakers have embarked on a quest for solutions to fight childhood overweight and obesity.

Unfortunately, these efforts have had only limited success as of yet, as policies and interventions that ensued from prior studies have been unable to turn the tide on children's weight gain. Therefore, bolder steps are required to address this preventable condition. Research and policy need to switch from a focus on the dietary environments and behaviours of individual children and their families in the home or school setting to targeting the physical, economic and political structures in which childhood overweight and obesity thrive. In recent years, especially in Health Geography, awareness has been raised about the myriad ways in which place relates to out-of-school physical activity, thereby suggesting pathways to tackle the epidemic of excess weight among children. However, I identified several major issues with this current approach at the start of my doctoral degree. The persistent null-findings and counterintuitive or unexplained statistical trends emerging from the predominantly positivist research were unable to alter conventional, archaic approaches to childhood overweight and obesity, and thus needed to be urgently remedied.

My doctoral research therefore aimed to investigate how the built environment, a factor which remains underexplored to date, is associated with children's extracurricular physical activity and body shape. Meeting this objective allows a deeper, more coherent understanding of this triad, and enables the development of activity and obesity policies that hold the potential to be truly effective. The systematic literature review pointed to the need to step away from the solely positivist approach characterising the majority of prior studies. Therefore, I adopted an explanatory sequential mixed-methods research design. This design combines the power of quantitative spatial epidemiology with the strengths of a qualitative, context-specific exploration of participants' lived experiences in situ. Using mixed-methods research to focus on the creation of leptogenic built environments in which physical activity is set then has the additional advantage of avoiding a narrative of individual responsibility and blame. It takes away the stigma generated by currently prevailing research and ensuing public health policies targeting the attitudes of individuals, families or small population groups.

The United Kingdom, branded the 'fat man of Europe', and in particular its capital London, consistently claiming a top spot on the list of global cities with the highest rates of childhood obesity, formed the research setting for this investigation. Within this setting, the first, quantitative research strand combined cartography, exploratory binary statistics and formal data modelling for a representative sample of over 1,800 London primary schoolchildren. The second, qualitative strand then included an ethnically diverse sample of 57 boys and girls aged seven to eleven residing in various parts of the London Boroughs of Newham and Brent. For these participants, a detailed picture of their daily micro-level, lived neighbourhood experiences was constructed while commuting to or from school, or performing outdoor, out-of-school physical activity. They were assigned the empowering role of local experts during go-along interviews, and their narratives were complemented with an insight into their regular daily physical activity through accelerometry and activity diaries.

The vastly different lenses adopted in both research strands called for their different operationalisation. In the first, quantitative research stage, six predefined built environmental characteristics for which current evidence was lacking or equivocal were retained, and linked to children's extracurricular physical activity and body composition. The central research question developed for this set of characteristics – comprising proximity to school and recreation facilities, traffic risk, personal risk, air pollution, walkability and the foodscape – was:

> *"Controlling for potential confounders, are rates of childhood overweight and obesity in London primary schoolchildren spatially and statistically associated with [this] predefined set of built environmental characteristics, selected based on an extensive literature review, that foster or hinder their extracurricular physical activity?"*

The spatial epidemiological analysis showed that the built environment was strongly implicated in the childhood obesity epidemic. This relation was, however, not direct: physical activity proved to be the indispensable pivot mediating the link between urban environments and body shape. Moreover, the evidence on the diverging effects of children's modes of commuting to school and out-of-school sports and exercise participation on their fat and fat-free mass underlined that it was crucial to disentangle overall extracurricular physical activity and total body mass metrics into their prime components. While active commuting to school was associated with the reduced fat mass of children, an increased frequency of extracurricular sports and exercise was significantly correlated with higher fat-free mass accretion. This highly revealing distinction could only be made through the use of the fat and fat-free mass indices, specifically designed for this study. In contrast, BMI, the measure of overweight and obesity most commonly used in prior research, was not able to detect body composition variations by activity component, entailing possible misclassification. BMI was also found to overestimate body fat among black children and muscle mass among children of South Asian ancestry. As bio-electrical impedance analysis becomes cheaper and more widely available, the possibility of using FMI instead of BMI where practical, affordable and in line with cultural understandings of body weight should be considered in future childhood obesity research, as this could significantly reduce the risk of flawed and inconclusive findings.

Separating out both core extracurricular activity components, the inverse associations between active commuting and reduced adiposity were particularly relevant. As this form of physical activity was also strongly correlated with the built environment, it offers a potential pathway to tackle both childhood inactivity and overweight and obesity. Proximity to school and commuting routes with safe traffic conditions stood out as the prime built environmental facilitators of active school travel. Furthermore, the cartography and statistics also revealed hotspots of risk factors for active commuting. Walking or cycling to school was often performed in environments characterised by high densities of highly polluting motorised transport, an unhealthy foodscape and high crime rates. The multilevel models also allowed identification of specific groups requiring particular attention. Firstly, black children were less likely to actively commute to school, and also had higher fat levels compared to their white or South Asian peers. Secondly, participants from more affluent family backgrounds showed elevated levels of passive commuting, tied to higher car ownership.

In contrast to the findings for commuting, children's self-reported frequency of participating in extracurricular sports and exercise showed no direct associations with the predefined built environmental characteristics in their home environments. While the limitations of using a subjective activity measure should be acknowledged, this form of out-of-school activity was only significantly associated with the muscle development of youngsters, and not with their fat mass. This implies that, although sports and exercise are important in ensuring children's healthy body composition, the pathway via active commuting might be more promising in the fight against childhood overweight and obesity.

These findings, which due to their cross-sectional nature and inclusion of self-reported variables should be interpreted with caution, underline that the spatial epidemiology in the first research stage was able to build a comprehensive, quantitative image of the dynamics at work in the triad connecting the built environment to children's out-of-school activity and body composition. However, the cartographic and statistical analyses were not able to specify what drives the observed patterns, and missed the context-specificity to propose local, evidence-based measures that could effectively drive down the levels of childhood overweight and obesity. This crucial information could be obtained by answering the second, qualitative central research question:

> *"How do London primary schoolchildren, with and without overweight or obesity, experience and use characteristics of their built environment from an energy-expenditure perspective?"*

While the qualitative results confirmed the importance of proximity and traffic safety in stimulating active commuting to school, they also revealed additional built environmental factors crucial to stimulating active transport. These included, first and foremost, the need for well-maintained pavements and safe crossroads. Moreover, this research stage also exposed the societal narrative opposing (independent) active travel. This socio-culturally determined behaviour was reinforced by school and local Council policies actively ruling children out of the public space.

Children's participation in sports and exercise, the second primary extracurricular physical activity component, was pushed back to clearly demarcated areas of greenspace and (indoor) recreational facilities. These were set at a distance of the direct road environment, which was perceived as too hazardous. Looking at the spatialities to which children were consequently bound, the lack of diverse and well-maintained amenities, the policies and spaces tailored to benefit cars and dogs over children, as well as the absence of cohesive social networks in the local community all contributed to hampering children's frequent participation in out-of-school sports and play. Hence, schools and surrounding areas of greenspace remained the primary source of physical activity provision for children. This finding was supported by the accelerometry, as children collected over half of their daily minutes of MVPA during school hours on weekdays.

Both quantitative and qualitative components thus provided undeniably highly insightful information to address the double epidemic of children's inactivity and excess weight. However, my doctoral research goes above and beyond the independent strengths of these two separate strands of research. The true power of mixed-methods research lies in their joint consideration by answering the third, integrative central research question, in search of convergence, discordance and expansion:

> *"How do the qualitative findings compare and relate to the quantitative results and help to interpret them?"*

By mixing quantitative and qualitative results, the evidence on the strong relations and dynamics at work in the triad connecting the built environment to children's extracurricular physical activity and body composition was emphasised. Active commuting to school was shown to be a source of continuous light-to-moderately intense activity, holding great potential to lower children's levels of body fat, and closely tied to the physical environments around school and along the commuting trajectory. Using the human ecological model developed in the conceptual framework, proximity, traffic safety and well-maintained and safe pavements and crossroads stood out as built environmental elements that need to be addressed with priority. The model also revealed additional habitat, behavioural and population vertex components constituting significant drivers of, or severe hurdles to, children's active school travel. These included common anxieties relating to darkness or the presence of large dogs, as well as a fear of strangers which were, at times, materialised and visibly present in the neighbourhood. Moreover, school and Borough policies were found to rule out independent active commuting to school, especially for younger children, by requiring permanent adult supervision. In contrast, remote supervision enabled by modern technology could meet this socially engrained desire for constant surveillance.

With regard to extracurricular sports and exercise, the absence of statistical associations for this muscle-stimulating physical activity component with built environmental characteristics was clarified by the qualitative data. Being confined to car-free areas of greenspace and recreation facilities because of traffic risk, this form of activity was found to be stimulated by the provision of well-maintained, challenging amenities in these spatialities – aspects which should be accounted for in future quantitative studies. Moreover, the presence of others, facilitating collective sports or play, was even more crucial than was the case for active commuting, underlining the need to build a cohesive social network. The fears and anxieties experienced by children and their caretakers described for school travel were observed for this form of out-of-school activity as well.

Whilst being highly labour- and time-intensive and requiring the researcher to master a wide set of quantitative and qualitative analytical skills, mixing methods and combining cartographic, statistical and narrative data thus proved highly fruitful. The compatible set of research methods employed delivered a wide range of complementary perspectives, making them ideally suited to be used together in a single study. The active integration of research stages was key to gaining a more comprehensive insight into the triad of the built environment, physical activity and body composition. This evidence, obtained through triangulation, was far greater than the information provided by the separate, constituent stages. It thereby increased the overall validity and credibility of results, allowing for a broader generalisation of study findings. At the same time, combining the strengths of qualitative and quantitative research also significantly mitigated their respective limitations.

Future work should therefore adopt a similarly ambitious mixed-methods approach in urban environments across the UK and beyond, in search of both city-wide trends and the context-specific drivers of weight that need to be tackled in order to drive down childhood overweight and obesity. It should account for the limitations of quantitative cross-sectional analyses and self-reported activity variables, as well as the challenges of carrying out go-along interviews and accelerometry, highlighted in this research. Moreover, future studies should consider the inclusion or development of additional variables, in particular in relation to walkability. The go-alongs showed the importance of aspects of maintenance, greenness and personal experience, which could be included in a new, child-centred walkability metric.

Translating these overall outcomes into policy recommendations, the practical and grounded nature of the qualitative stage also stimulated the divulging of information to larger audiences. Besides academics, also schoolchildren, caretakers, headmasters and local politicians and policymakers should be engaged in the implementation of research findings. Therefore, I produced two Borough policy papers, which I presented to the Borough Council's Public Health Departments in both Newham and Brent, as well as participating schools. Moreover, I was invited to present expert evidence to Brent Council's Childhood Obesity Task Group, feeding directly into the Borough's childhood obesity strategy via the Group's report published in March 2020. Reaching these broader audiences was facilitated by attaching powerful images and children's real-life narratives to the objective statistical observations, allowing me to meet the political aim of my study. By working together with Borough Councils towards the adoption of childhood activity and obesity policies, and actively involving schools and – of course – the children themselves, I believe I have engendered real change in children's lives in London, having boldly and seriously addressed activity patterns and body shapes.

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Appendix 1 – Informed Consent Forms for Participating Parents/Guardians and Children

Child Activity in the Home Neighbourhood Interviews –

Informed Consent Form for Parents and Guardians

Through this Informed Consent Form, I, Lander Bosch, PhD Student at the University of Cambridge, seek for your consent to invite your child to participate in the 'On Shape and Being Shaped'-study, focusing on child activity in the home neighbourhood. The form has two parts:

1) The information sheet, which shares information about the study with you.
2) The certificate of consent, which you can sign if you agree that your child may participate in the study.

You will be given a full copy of this form. You can find more elaborate and detailed information in the 'Additional Information Booklet' that accompanies this Informed Consent Form. You do not have to decide today whether or not you agree to let your child participate, and you can talk to anyone you feel comfortable with about the research. If you agree, you can sign the statement below. Only if both you and your child agree, I can start the research.

PART 1: Information sheet

<u>Aim of the research</u>

My research aims to understand the elements of neighbourhoods in London that make children want to go outside and play, do sports or walk/cycle to school, and how that impacts their health.

<u>Research steps</u>

If your child would participate in the research, she or he will be asked to engage in three activities:

1) **Participation in a go-along interview**, accompanied by you or a person of your choice on a day and time that suits you best. There are two options for the interview. The first option is that I follow the route to school your child usually takes (walking, cycling, or by car or public transport), while talking to her or him along the way about the neighbourhood we cross. The second option is that your daughter or son guides me around your neighbourhood and points out what she or he likes or dislikes about the environment along the way. The interview will be recorded, and the route tracked with a GPS, so that I know where we went afterwards.
2) **Wearing an accelerometer to measure physical activity**. I will ask your daughter or son to wear an 'accelerometer' during the interview and in the week thereafter. This small device records your child's daily activity. It should be worn during waking hours except during activities that involve water.
3) **Keeping an activity diary**. I will ask your child to complete an activity diary before going to bed, with your help in case this would be advisable. In this diary, your child can write

down what kind of activities your child did that day. Upon completion, you can give her or him one of the stickers that come with the diary.

Time investment

The interview takes as long as the commute or the tour through the neighbourhood takes, but the aim is not to go over 1 hour, including preparation time. Fitting the accelerometer and completing the activity diary should not take more than 10 minutes every day for one week.

Risks and benefits

The interview takes place outside. This involves exposure to varying weather conditions and traffic, and the chance of bumping into other people or animals that move in the neighbourhood. To limit risks, high-visibility jackets will be worn, and only safe paths will be followed. Moreover, a first-aid kit, umbrella and a fully-charged mobile phone with mapping application will be carried at all times. If we run into a friend, family member or acquaintance during the go-along, this may break the anonymity of the interview.

Participation of your child to the research is important to the understanding of what elements in the environment makes children want to go outside, play, do sports and walk to school. There will not be a financial reimbursement for participation in the study.

Confidentiality and sharing of research findings

Everything being discussed and all information gathered is strictly confidential. The privacy of you and your daughter or son is guaranteed. The only exception in which I am obliged to breach this confidentiality, is the case where criminal information is disclosed. All information will also be fully anonymized when included in my PhD dissertation, and potentially also research articles, presentations and public policy recommendations. I will fully comply with the Data Protection Act (https://www.gov.uk/data-protection).

Right to refuse or withdraw

Participation of your child is completely free and voluntary. Choosing to say no in no way influences the relation between you, your child, the school and/or the research. You can withdraw agreement at any point.

Who to contact

Mail: Lander Bosch
Department of Geography
University of Cambridge
Downing Place
Cambridge CB2 3EN
Email: lsmmb2@cam.ac.uk - Phone: 07460 661577

PART 2: Certificate of Consent

Statement by the parent/guardian

I have been asked to give consent for my daughter/son to participate in this research study on the activity of children in their neighbourhood. The study will involve a go-along interview and the collection of data through accelerometry and an activity diary.

I have read the information above, or it has been read to me, and have received the booklet with additional information about the research accompanying this Informed Consent Form. I have had the opportunity to ask questions, and any questions I have asked have been answered to my satisfaction. I consent voluntarily for my child to participate in this study.

Print name of parent/guardian: ____

Signature of parent/guardian: ____

Date: __________/_________/______________ (Day/Month/Year)

Statement by the researcher

I provided an accurate copy of the informed consent sheet and booklet with additional information about the research to the parent/guardian of the potential participant, and to the best of my ability made sure that the person understands the purpose, procedures, risks and benefits of participation. I confirm that the parent/guardian was given an opportunity to ask questions about the study, and all the questions asked by her/him have been answered correctly and to the best of my ability. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily.

Print name of researcher: ____

Signature of researcher: ____

Approval of the research

This project has been approved by the University of Cambridge, Department of Geography Research Ethics Committee (#698), and the Disclosure and Barring Service (#001598889152; formerly known as CRB).

UNIVERSITY OF CAMBRIDGE

Child Activity in the Home Neighbourhood –

Informed Consent Form for Children

Hi, my name is Lander Bosch and I am a student at the University of Cambridge. This document explains my research called 'On Shape and Being Shaped', which I would like you to be a part of. This document has two parts:

1) An 'information sheet'. This explains the research.
2) A 'certificate of consent'. There, you can sign if you want to be part of the study.

You will get a copy of this document to keep, and the little booklet that comes with it explains the research in more detail. You can ask your parents to look after it if you want.

PART 1: Information sheet (this explains the research)

<u>What is this research about?</u>

I want to know if and why children of your age are active outside. I am interested in how you go to school, and if you play, do sports, cycle… outside, and why that is. So, I would like to talk to you about what you like and don't like about your neighbourhood. I would like to know what you like or don't like about the places you cross when going to school as well.

<u>What is going to happen?</u>

If you want to be in this research, three things will happen:

1) I will ask if I can go to school together with you one morning, or if you want to give me a tour of your neighbourhood. Along the way, I would like you to tell me what you like and don't like about the streets we pass. I will wear a GPS system that tells me precisely where we are along the way as well. Your mum, dad or another person you know well will be there with us as well at all times.
2) I will ask you to wear a little machine called an 'accelerometer' during the time we spend together and the week after that. This machine will record how active you are during the day.
3) I will also ask you to fill out a diary every evening before going to bed for a week. In this diary, you can write what activities you've been up to that day. For every day you write in the diary, you will get a sticker from your parents/guardians. You can ask your mum, dad or anyone else to help you fill out the diary.

<u>How long will the research take?</u>

Going to school with you will take as long as it normally takes you to go to school. The tour through your neighbourhood will take about an hour at most. Filling in the activity diary and putting on the accelerometer takes a couple of minutes every day for a week.

Is the research dangerous?
No, we are not going to do anything that you would not normally do.

Who will know about you being part of the research?
No-one will be able to find out what you said. Only if you tell me about something that can hurt you or other people, I may have to talk about that to other people. Of course, when we bump into someone you know along the way, that person may know you are part of the research.

Who will know about the results of the research?
I am a student at university, so I will have to write the results of this research down. I may also present the results to other people.

Do you have to do this?
You can be part of this research, but only if you and your parents/guardians want to. If you feel like you don't want to be a part of the research anymore you can just tell me. It's ok to change your mind.

Who can you talk to and ask questions?
You can talk to anyone you like about this, and ask me questions at any time. My contact details are in the little booklet that comes with this form. You can also ask your parents to contact me. They know how to reach me as well.

PART 2: Certificate of Consent

For you to fill out if you want to be part of the research:

I know that this research is about trying to understand what I like and do not like about my neighbourhood and/or my route to school. I understand that Lander wants to talk to me about this, and that he will ask me to wear an accelerometer and fill out an activity diary. I asked any questions I had and am happy with the answers to them. I agree to be a part of this research.

My name: ____

My signature: ____

Date of today: Day: _____________; Month: _____________________; Year: ____________

If informed consent form was read/illiterate:

Statement by the witness:

I have witnessed the accurate reading of the consent form to the child, and she or he has had the opportunity to ask questions. I confirm that she or he has given consent freely.

Print name of witness (not a parent): ____

Signature of witness: ____

Date: ____ (Day/month/year)

Thumb print of participant:

Statement by the researcher

I have accurately read or witnessed the accurate reading of the assent form to the potential participant, and the individual has had the opportunity to ask questions. I confirm that the individual has given consent freely.

Print name of researcher: ____

Appendix 2 – Go-Along Interview Protocol

Prior to the start of the interview

Go-along interviews start at the place of residence of participants for interviews on the way to school and guided tours around the home neighbourhood, or at the school gate for interviews on the way home after school. Disruption of the family's daily routine should be minimized at all times, especially on busy weekday mornings before family members set off to work and school. Hence, I will ensure to arrive precisely at the agreed time at the participant's home or school. In case the interview starts at the family home, no assumptions are made whether I will be invited into the home, or whether I will be actively introduced to all individuals present there. After being introduced to the participating child and the accompanying individual, both are thanked for their willingness to participate in the research, and preparations are made to start the interview.

Start of the interview

At the start of the interview, in addition to the information distributed along with the informed consent form, the child is orally introduced to the go-along interview, its purpose and the equipment used. This introduction has the aim of actively engaging the child, and reassuring her or him about what a go-along entails. The following text is the exemplar introduction:

"We will walk to school/drive to school/walk around your neighbourhood (select as appropriate) *together today. I don't know this area because I have never lived in London. So, you're really the expert. You'll be in charge of where we're going and you decide the route we will be following. While we're walking, you'll be wearing this little machine. This is called an accelerometer. It measures how much we're moving during our trip. I also have a recorder, and a portable GPS, which allows me to see the route we follow. That way, I don't have to write everything down what we talk about today, and I can see where exactly we've been walking afterwards. The goal of our trip is for you to tell me which things you see or think about as we're walking that make you want to go outside and play, do sport or walk to school. Also, I would like to know what makes you don't want to go outside to play, do sport or walk to school. By playing and doing sport, I mean every activity except for sitting, like walking, cycling, going to a playground or park, playing games with your friends... So, think about all*

the fun and not fun things in your neighbourhood that make you like or dislike being active outside, and how you feel about them. As you are in charge, you can tell me freely about your own ideas and opinions, so I can learn from them. I may ask you some extra questions to make sure I completely get how you feel about the things we are going to talk about. One more important thing: nothing you say today is wrong or right, and if you feel at any point like you want to stop walking or discussing things with me, then just tell me and I'll let you go home/to school (select as appropriate) *straight away without any more questions.*

Do you have any questions about this? (Give opportunity to ask and respond to questions) *Ok, we're about to head off! A quick question as a warm-up: do you like to go outside and play, do sport or walk to school? What kind of things do you usually do when you're outside?"*

Topic list to be used during the interview

After participants' questions are answered, the GPS and audio recorder are switched on and the accelerometer is fitted. From that moment onwards, the child is considered the expert in her or his home neighbourhood or along the way to school, and invited to discuss any barriers or facilitators to outdoor physical activity or active commuting she or he experiences along the way. Whilst the interviews are child-led and ideally take the form of a two-way conversation rather than a one-directional questioning, a list of prompts can be used in an open framework to stimulate the discussion of these built environmental elements and to get more detail. These pointers are based on the insights into the dynamics at work in the built environment–child physical activity–body composition triad gained through the literature review and quantitative stage, and can be grouped into two broad categories:

1) Objective physical activity barriers and facilitators, following the six key quantitative variables. Exemplar questions include:

    a. Proximity: *Is there a place nearby where you can play or be active? Is it easy to get there, and why (not)?*
    b. Traffic risk: *How do you feel about cars along the way as you walk to school or in your neighbourhood?*
    c. Personal risk: *How do you feel about other people along the way as you walk to school or in your neighbourhood?*

d. Air pollution: *Do you feel like the air is clean in this neighbourhood or along the way to school? What do you think makes the air dirty?*
e. Walkability: *Where do you usually walk to in your neighbourhood? Do crossings or many people walking outside make that easier or harder for you?*
f. Foodscape: *Do you sometimes stop to buy something to eat or drink along the way, or do you walk over to stores from home? Where do you go?*

2) Built environmental perception. Exemplar questions include:
   a. *If you could add something to your neighbourhood that would make you go outside more to play or walk to school, what would it be?*
   b. *What is the nicest thing about your neighbourhood that makes you want to walk/cycle/drive to school or be active outside?*
   c. *What is the worst thing about your neighbourhood that makes you want to* (opposite mode of commuting) *to school or stay inside?*

Following the interview: further proceedings

When the end point of the interview, either the school gate or home, is reached, the interview is concluded by thanking the participant and accompanying individual, and the next research steps are explained. The following text is the exemplar conclusion:

"We've now reached home/school (select as appropriate)*, and I'll stop the interview here. Thank you so much for taking the time today and allowing me to accompany you. Before we say goodbye, please let me explain the next steps in the research a little bit, if that is alright with you. As I wrote in the booklet I gave you, over the course of the next week, I'd like you to do two things. First of all, I'd like to ask you to wear the accelerometer every day from the moment you wake up to the moment you go to bed. You can fit it like we did it just now, to make sure it's comfortable to wear. Just remind to take it off when you do an activity that involves a lot of water, like taking a bath or swimming. Secondly, at the end of each day before you go to bed, it would be great if you could fill out this activity diary* (hand activity diary and pen)*. There is a page for each day, asking you what activities you did that day and how long they took. You can ask anyone you like to help you with completing it. After a week, just bring the accelerometer and diary to school and give them to reception, and that's it! Once again, if you feel like stopping participating in the research, you are free to do so. Also, if there is*

anything you want to ask me or let me know throughout the week, all my contact details are in the booklet, so you can reach me at any time. Is that alright with you? Do you have any questions? (Give opportunity to ask and respond to questions).”

Once all final questions are answered, the child and accompanying individual are thanked once again, and the interview is officially ended.

Appendix 3 – Article Bosch et al. 2019; BMC Public Health

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BMC Public Health

RESEARCH ARTICLE Open Access

Associations of extracurricular physical activity patterns and body composition components in a multi-ethnic population of UK children (the Size and Lung Function in Children study): a multilevel modelling analysis

Lander S. M. M. Bosch[1*], Jonathan C. K. Wells[2], Sooky Lum[3] and Alice M. Reid[1]

Abstract

Background: Body Mass Index (BMI) is a common outcome when assessing associations between childhood overweight and obesity and physical activity patterns. However, the fat and fat-free components of BMI, measured by the Fat Mass Index (FMI) and Fat-Free Mass Index (FFMI), may show contrasting associations with physical activity, while ethnic groups may vary in both physical activity patterns and body composition. Body composition must therefore be evaluated when assessing the associations between childhood overweight and obesity and physical activity in multi-ethnic populations.

Methods: This cross-sectional study investigated associations of BMI, FMI and FFMI z-scores with extracurricular physical activity for 2171 London primary schoolchildren (aged 5–11 years) of black, South Asian and white/other ethnicity. Multilevel mixed-effects ordered logistic modelling was used, adjusting for age, sex and family and neighbourhood socioeconomic status as potential confounders.

Results: Controlling for ethnicity and individual, family and neighbourhood socioeconomic confounders, actively commuting children had significantly lower Odds Ratios for being in high BMI (Odds Ratio (OR) = 0.678; 95 % Confidence Interval (CI) = 0.531 – 0.865; $p-$value = 0.002) and FMI z-score groups (OR = 0.679; 95 % CI = 0.499 – 0.922; p = 0.013), but not FFMI z-score groups, than passive commuters. Children doing sports less than once a week had lower Odds Ratios for being in high BMI (OR = 0.435; 95 % CI = 0.236 – 0.802; p = 0.008) and FFMI (OR = 0.455; 95 % CI = 0.214 – 0.969; p = .041) z-score categories compared to daily active children. Differences in FMI between groups did not reach the significance threshold. A trend towards statistical significance was obtained whereby children's complete inactivity was associated with higher odds for being in higher BMI (OR = 2.222 : 95 % CI = 0.977 – 5.052; p = .057) and FMI z-score groups (OR = 2.485 : 95 % CI = 0.961 – 6.429; p = .060). FFMI z-scores did not show a similar trend with complete inactivity.

Conclusions: Active commuting was objectively associated with lower adiposity, while more frequent extracurricular sports participation was correlated with greater fat-free mass accretion. These relationships were independent of ethnicity and individual, family or neighbourhood socioeconomic confounding factors.

Keywords: Body composition, Fat mass, Fat-free mass, Extracurricular physical activity, Ethnicity, Childhood overweight and obesity, Epidemiology, Health geography

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Background

Excessive fat accumulation in children is a major risk factor for a plethora of short-term physical and socio-psychological health conditions, as well as for early-onset morbidity and mortality in adulthood [1, 2]. Body Mass Index (BMI) is still the most widely adopted index of children's fatness, as its simplicity and the low cost of data collection and interpretation are useful when measuring large samples. However, the limitations of using BMI in the study of childhood overweight and obesity are well-established [3], as it does not differentiate fat and fat-free body mass components [4, 5]. Moreover, both BMI itself and the thresholds at which high BMI is associated with ill-health vary with age, sex and ethnicity [6].

The development of age- and sex-adjusted BMI z-scores for children aged 5 to 19 years old resolves the issue of age and sex variability [7]. Conventionally, the cut-off points for overweight and obesity are set at the 85th and 95th percentile boundaries, respectively [8]. However, BMI z-scores systematically underestimate body fatness in South Asian children, while overestimating adiposity in black African children [9, 10]. One way to remedy this is to apply adjustment factors, recently published for these ethnicities in British 4- to 12-year-olds [11]. However, the lack of direct data on body composition hinders elucidation of the underlying, multifactorial drivers of ethnic differences in obesity risk, such as genetic, socioeconomic, cultural and family routine variables [12]. Similarly, the different health implications of fat and fat-free mass make the distinction between them vital in the determination of the risks posed by adiposity, as obesity-related health risks are primarily the consequence of excessive fat accumulation rather than total weight [4, 5].

These differential health implications are particularly relevant when studying the associations of physical activity (PA) with childhood overweight and obesity. PA not only contributes to fat oxidation, but may also stimulate muscle development [13]. Increased PA, and consequently fat-free mass, could therefore entail a higher overall BMI. However, the impact of PA on body composition and BMI and its potential health benefits means that high BMI due to high PA has very different implications compared to high BMI deriving from high fatness. BMI thus needs to be divided into fat and fat-free body mass indices, abbreviated as FMI and FFMI respectively [14, 15].

Study aim

We aimed to study the association of PA with body composition in a multi-ethnic sample of UK primary schoolchildren. Ethnicity was taken into account with the objective of demonstrating more reliably the association of both components of body composition with the two prime contributors to children's daily extracurricular PA [16]: competitive or leisurely sports participation outside of school hours, and active commuting to and from school.

Methods

Participants

This cross-sectional analysis used data from a sample of London primary schoolchildren who participated in the Size and Lung Function in Children (SLIC) study carried out at the Great Ormond Street Institute of Child Health, University College London, UK [17]. Between December 2010 and June 2013, data on body composition, PA and socioeconomic status were collected for 2171 children aged 5 to 11 years, attending thirteen schools in London. These schools were purposefully sampled based on their diverse geographical location and education performance. Moreover, schools were selected to have strongly diverging ethnic compositions. Together, this ensured the collection of a SLIC sample with a broad spectrum of ethnic and socioeconomic backgrounds [17, 18]. Further detailed information on the recruitment of schools and participants, their representativeness and data collection methods of the SLIC Study can be found elsewhere [17, 18].

Measures

Anthropometric and body composition data were collected by the SLIC team during school visits. These included the child's height in centimetres, total body mass in kilograms, and fat-free body mass (FFM) in kilograms estimated from bio-electrical impedance analysis (BIA) using standard instrumentation (Tanita BC418, Tanita Corporation, UK). FFM was calculated from raw BIA data using the multi-ethnic calibration equation of Lee et al. [19], generated from the same population using deuterium dilution as the reference method. Fat mass (FM) in kilograms was calculated by subtracting the FFM from total body mass.

BMI for SLIC children was calculated by dividing total body mass in kilograms by the square of their height in metres. These were converted to age- and sex-specific percentiles using the 2007 World Health Organization BMI reference charts [20]. Analogous to the calculation of BMI, FFM and FM were then divided by the square of height in metres to give fat-free mass index (FFMI) and fat mass index (FMI). The need for age- and sex-adjusted FMI and FFMI reference charts, similar to those for BMI, has been highlighted in prior research, and these have been developed for specific groups of children [21–24]. However, no adequate reference charts currently exist for the age group and ethnic mix of our sample of UK participants. Hence, the raw FMI and FFMI scores were further converted to within-study age- and sex-specific z-scores using multiple regression analysis. Age- and sex-adjusted z-scores and percentiles of FMI and FFMI are thus sample-specific, though they can be considered to be representative for the London-wide population of primary schoolchildren aged 5–11, given the large diversity in terms of age, sex and ethnicity of included participants [17, 18]. To address skew, FM was first natural log-transformed.

Following the guidelines of the Centers for Disease Control and Prevention [8], the 5th, 85th and 95th percentiles were used as class boundaries to assign each individual child in the SLIC database to one of four categories of age- and sex-adjusted BMI (underweight, normal weight, overweight or obese). In analogy, age- and sex-adjusted FMI and FFMI of SLIC children were also subdivided into four categories, which were designed to be equivalent to the categories for BMI (low, normal, moderate or elevated FM and FFM for height, respectively). Hence, for both FMI and FFMI measures, the 5th, 85th and 95th percentiles were selected as class boundaries.

Data on SLIC children's extracurricular PA were also directly collected via a questionnaire during the school visits for two key components of their extracurricular activity [16]. Firstly, the frequency of participation in a series of twelve sports was gauged. These included the potentially low-cost activities of running/jogging and cycling, regular outdoor activities (football, cricket, skating/rollerblading), regular indoor activities (gymnastics, swimming, badminton/tennis, basketball, dancing, judo/boxing, weightlifting) and an 'other' category where less common sports could be indicated. Possible frequencies ranged from 'never' through 'less than weekly', 'weekly' and 'most days' to 'daily'. A composite measure was constructed, providing an overview of the overall sports participation of each child. Second, children were asked for the dominant mode of transport when commuting from home to school. Afterwards, parents and guardians were asked the same question through a parental questionnaire. Responses were classified as 'active commuting' if the child predominantly walked or cycled, or 'passive commuting' where car, bus or metropolitan railway/underground were the dominant modes of transport. If both active and passive transport constituted significant parts of the commute, this was labelled 'mixed commuting'. Where parent and child responses differed, this was retained by their inclusion in a 'disagreement' category.

Data on sex, age and attended school of participating children were directly collected during the school visits. Parents/guardians were asked to provide detailed information on their child's ethnicity via a questionnaire [17, 18]. Based on this information, children were categorized into three main ethnic groups: black (African or Caribbean ancestry), South Asian (ancestry from the Indian subcontinent) and white/other (European/other/mixed ancestry). The 'other' category is added to the 'white' category as over 70% of the 364 children belonging to this group of whom the ethnicity is known are half white, by far the largest proportion of any ethnicity. Socioeconomic data were also gathered via the questionnaire [17]. Family socioeconomic status was derived from an inventory of material possessions, summarized in the Family Affluence Scale [25]. Car ownership (zero to two cars) was accounted for separately, given its decisive role in commuting choices [26–28]. Whether or not the child received free school lunches, a reliable indicator of socioeconomic disadvantage in the UK [29], was included as a final indicator of family socioeconomic status. Using the child's postcode of residence, neighbourhood socioeconomic status was categorized using the 2010 Index of Multiple Deprivation, combining 38 weighted variables across seven domains of deprivation for small-area units [30]. These contextual data for the SLIC sample are summarized in Additional file 1: Table S1.

Analyses

Statistical analyses were performed in Stata 14.2 (StataCorp 2015, College Station, Texas, USA). χ^2-tests were performed to analyse binary relationships between ethnicity and body composition measures, PA and potential confounders. When analysing the associations of PA and body composition, the nested data structure, whereby pupils are grouped by school, needed to be accounted for. Individuals attending the same school are likely to be more similar to each other compared to those attending a different school [31, 32]. As non-white children in England are unequally confronted with socioeconomic and obesity risk factors [33], the distribution of and exposure to these risk factors differed by school, according to their ethnic composition. This clustering of more similar subjects in groups by school violates the assumption of independence of observations and generates a need for school-specific information [34]. Compositional effects must be distinguished from contextual ones. This can be done through a multilevel analysis on two levels [35]. The first level includes the PA of the child, as well as her or his individual characteristics (ethnicity, age and sex), and family and neighbourhood socioeconomic status. This captures the specific individual, socioeconomic environment she or he is exposed to. The second level then groups the children by the school they attend. This corrects for their higher likelihood of similarity due to the exposure to more similar environments based on their place of residence and school location. Simultaneously, the mixed-effects regression models designed for the analysis of clustered data must be adapted to fit the ordered categorical nature of the response variables for body composition. Hence, multilevel mixed-effect ordered logistic modelling was performed for BMI, FMI and FFMI on the level of the individual child and the attended school [36]. Results are shown as Odds Ratios

(OR) for being in higher BMI, FMI or FFMI categories, with 95% Confidence Intervals. The critical significance level for all models was set at $p < 0.05$. Participants for whom anthropometric, body composition, PA or Index of Multiple Deprivation data were lacking, or who were considered to be unhealthy at the time of data collection, were excluded from analysis.

Results

Descriptive statistics

For 1889 SLIC children who were healthy at the time of data collection, data were available for each of the anthropometric, body composition, PA and Index of Multiple Deprivation measures (87.0% of the total sample). Table 1 shows that for 18.7% of children, their age- and sex-adjusted BMI z-score percentile placed them in the obese category, with another 12.4% falling in the overweight category. For FMI, 9.1% had a score between the 85th and 95th percentiles, and another 6.1% scored above the 95th percentile. For FFMI, similar percentages were obtained. Results for self-reported extracurricular PA suggest that 44.1% of children engaged in sports every day, with only 1.4% being completely inactive. Nearly half of the children commuted actively to school. One-third predominantly used passive means of transport. In one out of five cases, however, parent and child commuting reports were inconsistent (21.1% of responses). Due to its size, this disagreement group has been retained as a separate category in the statistical models.

Table 1 Body composition and PA measures for the sample of SLIC children in the current study

Variable	Number of SLIC children	Percentage (%)
Age- and sex-adjusted BMI z-score		
< 5th percentile, 'underweight'	75	4.0
5th–85th percentile, 'normal weight'	1227	64.9
85th–95th percentile, 'overweight'	234	12.4
> 95th percentile, 'obese'	353	18.7
ln(FMI) z-score		
< 5th percentile	56	3.0
5th–85th percentile	1546	81.8
85th–95th percentile	172	9.1
> 95th percentile	115	6.1
FFMI z-score		
< 5th percentile	61	3.2
5th–85th percentile	1564	82.8
85th–95th percentile	167	8.9
> 95th percentile	97	5.1
General Sports Frequency		
Never	26	1.4
Less than weekly	73	3.8
Weekly	476	25.2
Most days	481	25.5
Daily	833	44.1
Dominant mode of commuting		
Active	883	46.7
Passive	598	31.7
Mixed	9	0.5
Disagreement child-parent	399	21.1

PA Physical Activity, *BMI* Body Mass Index, *FMI* Fat Mass Index, *FFMI* Fat-Free Mass Index

Further characteristics are summarized in Additional file 1: Table S1. 53.7% of the sample were female. All age groups between 5 and 11 years were well-represented, while black and South Asian children accounted for over half of the total sample. The majority of children lived in families with intermediate Family Affluence Scale scores, with a slight tendency towards higher affluence. Nearly a quarter received free school lunches. About a quarter of families did not own a car, while a similar proportion owned two. Most children lived in relatively deprived neighbourhoods, with 32.2% residing in an area in the most deprived quintile for the Index of Multiple Deprivation.

Binary statistics relating to ethnicity

Table 2 demonstrates that, using BMI, the proportion of black children with overweight or obesity (42.1%) was significantly higher than that for children of white/other ethnicities (29.9%) and South Asian children (22.5%). This contrast was reduced when FMI was analysed, although inter-ethnic differences remained significant. The proportion of South Asian children with FMI percentile over 95 was higher than in the white/other ethnic group (6.8% versus 4.0%). The largest differences were observed for FFMI percentile scores. 24.1% of children of black ethnicity had an FFMI percentile score above the 85th percentile. For the white/other group, this was 14.2%, for South Asians only 4.1%.

Ethnic groups differed significantly in their overall frequency of sports participation. 71.8% of black children and 72.2% of South Asian children in the SLIC sample participated in sports more than once a week. For those of white/other ethnicities, this was 66.7%. We found no significant inter-ethnic differences in commuting modes.

Additional file 2: Table S2 and Additional file 3: Table S3 illustrate further significant differences between ethnicities. Families of black children scored lower on the Family Affluence Scale compared to white/other families, with South Asians having intermediate scores. Car ownership was lower for black families than for white/other and South Asian families. The findings for free school lunches showed the opposite pattern. Families of

Table 2 Body composition and physical activity according to ethnicity

Variable	Ethnicity, n (%)			Chi^2-test
	Black	South Asian	White/Other	Pearson-χ^2; *p*-value
Age- and sex-adjusted BMI z-score				
< 5th percentile, 'underweight'	9 (1.8)	46 (8.9)	20 (2.3)	**88.8; <.001*** **
5th–85th percentile, 'normal weight'	275 (56.1)	353 (68.5)	599 (67.8)	
85th–95th percentile, 'overweight'	71 (14.5)	46 (8.9)	117 (13.2)	
> 95th percentile, 'obese'	135 (27.6)	70 (13.6)	148 (16.7)	
ln(FMI) z-score				
< 5th percentile	23 (4.7)	8 (1.5)	25 (2.8)	**39.7: <.001*** **
5th–85th percentile	359 (73.3)	435 (84.5)	752 (85.1)	
85th–95th percentile	63 (12.8)	37 (7.2)	72 (8.1)	
> 95th percentile	45 (9.2)	35 (6.8)	35 (4.0)	
FFMI z-score				
< 5th percentile	7 (1.4)	46 (8.9)	8 (0.9)	**163.6; <.001*** **
5th–85th percentile	365 (74.5)	448 (87.0)	751 (85.9)	
85th–95th percentile	62 (12.7)	15 (2.9)	90 (10.2)	
> 95th percentile	56 (11.4)	6 (1.2)	35 (4.0)	
General Sports Frequency				
Never	5 (1.0)	4 (0.8)	17 (1.9)	**19.5; .013***
Less than weekly	21 (4.3)	21 (4.1)	31 (3.5)	
Weekly	112 (22.9)	118 (22.9)	246 (27.8)	
Most days	126 (25.7)	116 (22.5)	239 (27.0)	
Daily	226 (46.1)	256 (49.7)	351 (39.7)	
Dominant mode of commuting				
Active	204 (41.6)	249 (48.3)	430 (48.6)	10.4; .108
Passive	158 (32.3)	159 (30.9)	281 (31.8)	
Mixed	3 (0.6)	2 (0.4)	4 (0.5)	
Disagreement child-parent	125 (25.5)	105 (20.4)	169 (19.1)	

BMI Body Mass Index, *FMI* Fat Mass Index, *FFMI* Fat-Free Mass Index
*: $p < .05$; **: $p < .01$; ***: $p < .001$
Significant associations ($p < .05$) on the first level of the multilevel model are in bold

black children tended to live in more deprived neighbourhoods than the other groups. The ethnic composition of the schools also differed significantly.

Multilevel mixed-effect ordered logistic models linking body mass and composition to PA

The results of the multilevel mixed-effect ordered logistic models linking body composition to sports participation are shown in Table 3. Children of black ethnicity had significantly higher childhood overweight and obesity odds for BMI compared to the white/other group, and similar results were obtained for FMI and FFMI. For South Asians, the opposite findings were obtained for BMI and FFMI. Being younger was associated with lower weight status in terms of BMI. Socioeconomic differences were also evident. If the child received free school lunches, she or he had significantly higher odds for elevated BMI, FMI and FFMI, while a positive relationship between high Family Affluence Score and FFMI was found.

If only conventional BMI percentiles are taken into account, children who were active less than once a week had significantly lower odds of being overweight or obese compared to children who were active daily. The higher Odds Ratios for completely inactive children to be overweight or obese did not reach the significance threshold for BMI. This picture changes, however, as soon as FMI and FFMI are studied. Using these indexes of fat and fat-free mass, children who were active less than weekly were significantly less likely to belong to high FFMI categories compared to daily active children, whereas the results for FMI did not reach the significance threshold. A trend towards statistical significance was also obtained whereby

Table 3 The relationship between measures of body mass index and body composition and frequency of sports participation

Variable	BMI z-score percentile categories		ln(FMI) z-score percentile categories		FFMI z-score percentile categories	
	Wald Chi-Squared = 77.92; *p* < .001		Wald Chi-Squared = 85.47; *p* < .001		Wald Chi-Squared = 85.47; p < .001	
Level 1	O.R. [95% C.I.]	*p*-value	O.R. [95% C.I.]	*p*-value	O.R. [95% C.I.]	*p*-value
Sports Frequency (reference: daily)						
Never	2.222 [0.977–5.052]	.057	2.485 [0.961–6.429]	.060	1.816 [0.619–5.328]	.277
Less than weekly	**0.435 [0.236–0.802]**	**.008****	0.466 [0.210–1.341]	.061	**0.455 [0.214–0.969]**	**.041****
Weekly	0.970 [0.750–1.256]	.819	0.967 [0.697–1.341]	.841	0.945 [0.676–1.321]	.741
Most days	0.911 [0.707–1.174]	.471	0.998 [0.728–1.369]	.990	0.832 [0.596–1.162]	.281
Sex (reference: female)						
Male	0.843 [0.687–1.035]	.102	0.975 [0.754–1.261]	.846	1.063 [0.815–1.386]	.654
Age at test	**1.110 [1.041–1.183]**	**.001****	1.005 [0.928–1.089]	.903	1.030 [0.947–1.120]	.486
Ethnicity (reference: white/other)						
Black	**1.563 [1.183–2.066]**	**.002****	**1.809 [1.268–2.580]**	**.001****	**1.612 [1.130–2.300]**	**.008****
South Asian	**0.607 [0.452–0.815]**	**.001****	1.306 [0.920–1.854]	.136	**0.253 [0.157–0.408]**	**<.001*****
Family Affluence Scale (reference: low)						
Moderate	1.209 [0.816–1.792]	.344	1.344 [0.818–2.209]	.244	1.491 [0.892–2.492]	.127
High	1.107 [0.692–1.771]	.671	1.728 [0.959–3.112]	.069	**1.940 [1.052–3.574]**	**.034***
Free school lunches (reference: no)						
Yes	**1.426 [1.087–1.870]**	**.010***	**1.681 [1.211–2.334]**	**.002****	**1.582 [1.114–2.247]**	**.010***
Cars owned (reference: 0)						
1	0.988 [0.749–1.305]	.934	1.040 [0.737–1.466]	.824	0.987 [0.690–1.411]	.941
2	1.052 [0.731–1.513]	.787	0.872 [0.550–1.381]	.559	0.674 [0.414–1.097]	.113
Multiple Deprivation Index (reference: low)						
Intermediate	1.275 [0.914–1.780]	.153	1.116 [0.735–1.696]	.607	1.318 [0.846–2.053]	.222
High	1.385 [0.979–1.960]	.066	1.384 [0.910–2.103]	.129	1.314 [0.828–2.085]	.246
Level 2: Variance on School Level	0.053 [0.012–0.227]		0.048 [0.008–0.298]		0.112 [0.026–0.479]	

O.R. Odds Ratio, *C.I.* Confidence Interval, *BMI* Body Mass Index, *FMI* Fat Mass Index, *FFMI* Fat-Free Mass Index
*: $p < .05$; **: $p < .01$; ***: $p < .001$
Significant associations ($p < .05$) on the first level of the multilevel model are in bold

completely inactive children had significantly higher odds of belonging to the highest FMI categories compared to children who engaged in sports every day. FMI and FFMI trends for other sports frequencies were similar to those for BMI.

Table 4 shows the link between BMI or body composition, and commuting to school. BMI data indicate that active school commuting is associated with lower odds of childhood overweight and obesity compared to passive commuting. A similar finding was also obtained for FMI, but not for FFMI. Observations for mixed commuting and the disagreement category did not reach statistical significance.

Ethnicity and confounders showed the same pattern of association with BMI, FMI and FFMI in the commuting models as in the sports participation models, with the exception that high neighbourhood deprivation was now linked to significantly elevated childhood overweight and obesity measured by BMI.

Discussion

This study examined the associations of specific physical activity patterns with individual body composition components, accounting for ethnicity and individual anthropometric, family and neighbourhood socioeconomic variables in a multi-ethnic sample of UK children, drawn from the SLIC study.

To our knowledge, it is the first to assess the impact of PA on childhood overweight and obesity for primary schoolchildren by simultaneously relating two potential prime contributors to extracurricular physical activity, mode of commuting to school and frequency of sports participation, to children's body composition. PA has rarely been disaggregated in the study of its relationship to body composition, and no other study has specifically focused on the relationship between PA patterns and various measures of body composition for a large cohort of primary schoolchildren. Our findings show that active commuting to school is inversely associated with BMI,

Table 4 The relationship between measures of body mass index and body composition and mode of commuting

Variable	BMI z-score percentile categories		ln(FMI) z-score percentile categories		FFMI z-score percentile categories	
	Wald Chi-Squared = 82.02; *p* < .001		Wald Chi-Squared = 46.21; p < .001		Wald Chi-Squared = 87.64; p < .001	
Level 1	O.R. [95% C.I.]	*p*-value	O.R. [95% C.I.]	*p*-value	O.R. [95% C.I.]	*p*-value
Commuting mode (reference: passive)						
Mixed	0.471 [0.112–1.979]	.304	0.584 [0.099–3.463]	.554	0.751 [0.138–4.076]	.740
Active	**0.678 [0.531–0.865]**	**.002****	**0.679 [0.499–0.922]**	**.013***	0.918 [0.665–1.267]	.603
Disagreement	1.028 [0.769–1.375]	.850	0.994 [0.696–1.419]	.972	1.451 [0.998–2.110]	.051
Sex (reference: female)						
Male	0.856 [0.698–1.050]	.136	0.987 [0.763–1.275]	.918	1.085 [0.833–1.414]	.546
Age at test	**1.118 [1.049–1.191]**	**.001****	1.012 [0.935–1.095]	.770	1.034 [0.951–1.123]	.436
Ethnicity (reference: white/other)						
Black	**1.459 [1.104–1.927]**	**.008****	**1.698 [1.191–2.420]**	**.003****	**1.547 [1.084–2.209]**	**.016***
South Asian	**0.606 [0.453–0.813]**	**.001****	1.302 [0.924–1.837]	.132	**0.248 [0.153–0.401]**	**<.001*****
Family Affluence Scale (reference: low)						
Moderate	1.093 [0.738–1.618]	.658	1.208 [0.737–1.981]	.453	1.382 [0.827–2.307]	.217
High	1.024 [0.641–1.638]	.920	1.574 [0.875–2.832]	.130	**1.888 [1.026–3.474]**	**.041***
Free school lunches (reference: no)						
Yes	**1.412 [1.078–1.851]**	**.012***	**1.633 [1.178–2.265]**	**.003****	**1.534 [1.081–2.177]**	**.017***
Cars owned (reference: 0)						
1	0.961 [0.727–1.269]	.777	1.008 [0.713–1.426]	.964	0.990 [0.691–1.417]	.955
2	0.978 [0.679–1.409]	.904	0.819 [0.515–1.300]	.397	0.664 [0.407–1.082]	.100
Multiple Deprivation Index (reference: low)						
Intermediate	1.265 [0.910–1.760]	.162	1.132 [0.747–1.714]	.559	1.317 [0.849–2.043]	.219
High	**1.407 [1.010–1.961]**	**.043***	1.417 [0.949–2.116]	.089	1.332 [0.846–2.097]	.216
Level 2: Variance on School Level	0.045 [0.009–0.210]		0.036 [0.005–0.291]		0.092 [0.019–0.441]	

O.R. Odds Ratio, *C.I.* Confidence Interval, *BMI* Body Mass Index, *FMI* Fat Mass Index, *FFMI* Fat-Free Mass Index
*: *p* < .05; **: *p* < .01; ***: *p* < .001
Significant associations (*p* < .05) on the first level of the multilevel model are in bold

whereas earlier research has provided inconclusive evidence on its adiposity-countering effects [37, 38]. Interestingly, only when BMI is disentangled into its underlying fat and fat-free components, measured by FMI and FFMI, does it become apparent that the inverse relationship obtained is principally due to lower FMI and not FFMI for active commuters. This is in line with other studies looking specifically at adiposity [39, 40]. These findings are independent of children's ethnicity, age, gender or socioeconomic status.

Studying body composition also sheds light on the impact of sports participation. Frequent sports participation does not consistently lower a child's likelihood of being overweight or obese as defined by BMI. A large body of studies prior to ours has generated inconsistent findings on this relationship [41]. Whereas some studies found a BMI-lowering effect of sports throughout childhood and adolescence [42–44], others found no relationship [45, 46]. Again, only when considering FMI and FFMI separately, it is shown that that less-than-weekly sports participation is associated with lower FFMI, whilst there is a trend for completely inactive children to have higher fat masses. The lower FFMI percentile scores for children who are active less than once a week are likely due to reduced muscle development [3, 13]. Despite the more complex data collection process, it is thus indispensable to separately collect information on fat and fat-free mass.

Besides demonstrating the influence of PA components on BMI, FMI and FFMI, this study expands our knowledge of confounding factors that affect body composition. In addition to the standard anthropometric variables age and sex, which were accounted for through the use of z-scores and included as individual confounders, the mediating role played by ethnicity and socioeconomic status is underlined [47, 48]. Our analyses were able to address remaining uncertainties related to these confounders [47] by looking at the effect of ethnicity and socioeconomic status on the same individuals for whom BMI, FMI and FFMI data were available. Considering BMI, overall childhood overweight and obesity levels for the selected SLIC sample were comparable to those for primary schoolchildren at the national level, and slightly below the average for London [49]. However, first, strong inter-ethnic differences were evident. Higher childhood overweight and obesity rates were observed for black children, and lower rates for South Asians, in comparison to the white/other group. Using FMI, levels for children of black ethnicity were still consistently higher than those for any other ethnic group. Whilst not significant, the multilevel models showed that South Asians appeared more likely to be in the highest adiposity category than whites/others. Their lower BMI is hence related to their significantly lower fat-free mass development.

A broad range of family and neighbourhood socioeconomic confounders were then accounted for to further elucidate the ethnicity-body composition relationship, as children of different ethnicities were previously found to be unequally exposed to socioeconomic and environmental obesity risk factors [50–53]. In England, black and South Asian primary schoolchildren are more likely to have obesogenic lifestyles than whites [33]. The binary associations in our research indicate strong socioeconomic disparities between ethnicities. Families of black ethnicity scored significantly lower on the Family Affluence Scale and lived in more deprived neighbourhoods compared to the children in the white/other group, with South Asians having intermediate socioeconomic status. Yet, using multivariate models to correct for the association of ethnicity and family and neighbourhood socioeconomic variables, the significant association of ethnicity with body composition was found to be independent of socioeconomic conditions. Black ethnicity was associated with higher total, fat and fat-free body mass indices, and being of South Asian ethnicity with lower total and fat-free body mass compared to white/other children. This independent association of ethnicity with childhood overweight and obesity is in line with other research in the UK and elsewhere that finds ethnic differences to be only partially explained by socioeconomic characteristics [12, 54].

Our results have several broader implications. First, the finding that different modes of PA are associated with different body composition characteristics has to be considered in future research on the PA-childhood overweight and obesity relationship. The observation that active commuting is linked to lower FMI is especially relevant, given that adiposity has been shown to directly impact the short- and long-term morbidity and mortality of children with overweight and obesity [1, 2]. Interventions should therefore target factors that reduce FMI, as they are more likely to reduce the burden of the childhood overweight and obesity epidemic. Second, we would not have observed all the associations if we had looked only at BMI. Even stronger, healthy muscle mass, rather than excess body fat, might make frequently active children appear as overweight or obese when BMI is used as has been previously suggested [3, 13]. Additionally, BMI is influenced by ethnicity, making the use of accurate anthropometric data and a wide range of socioeconomic characteristics indispensable in the study of childhood overweight and obesity.

Our study also has limitations that need to be acknowledged. Being a cross-sectional study, a causal link between childhood overweight and obesity and PA could not be established. Next, although thoroughly selected and tested, it cannot be guaranteed that all relevant confounders have been included. Moreover, the use of three broad ethnic groups does not allow us to take other ethnicities and their differences at finer scales into account. In addition, both measures of PA rely on subjective self-report, and could not be objectively verified. Whilst no data were collected during the UK school summer holiday period during peak summer months (second half of July to October), seasonality potentially affecting outdoor, non-essential PA could not be corrected for. They also do not capture scheduled or free in-school activity, which may vary between pupils of different schools. Lastly, despite the specific ethnic, socioeconomic and geographically diverse sampling, findings for the SLIC dataset only apply to these primary schoolchildren in London. Caution needs to be exerted when expanding hypotheses beyond the scope of this sample.

Conclusion

Our study demonstrates how various extracurricular PA components predict body composition in a multi-ethnic population from varying socioeconomic backgrounds and, in so doing, contributes to the development of tailor-made interventions to counter childhood overweight and obesity. Moreover, it does so for children predominantly living in deprived conditions, where overweight and obesity tend to cluster. The findings suggest that future interventions could be particularly promising if they consist of a combination of the promotion of active commuting, lowering FMI, and sports participation, raising FFMI. Disentangling the core variables of the childhood overweight and obesity-PA relationship is indispensable for the development of informed policy measures that could contribute to the reversal of the childhood overweight and obesity epidemic. Notwithstanding their more complex data collection process, fat and fat-free body mass data need to be separately collected, to fully understand observed weight status trends, and anthropometric characteristics and socioeconomic status need to be corrected for. The same applies to PA: it needs to be disaggregated into its different components when its relationship with body composition is studied. The continuous omission of this disentanglement is likely to contribute to the substantial and growing body of literature describing counterintuitive and null-findings.

Additional files

Additional file 1: Table S1. Descriptive statistics for the sample of SLIC children included in the current study. (DOCX 13 kb)

Additional file 2: Table S2. Potential confounding variables by ethnicity. Table containing descriptive statistics and results of Chi^2-tests for potential confounding variables by ethnicity. (DOCX 15 kb)

Additional file 3: Table S3. Ethnic composition of SLIC schools. Table containing descriptive statistics and results of a Chi^2-test for the ethnic composition of SLIC schools. (DOCX 13 kb)

Abbreviations
BIA: Bio-electrical Impedance Analysis; BMI: Body Mass Index; CI: Confidence Interval; FFM: Fat-Free Mass; FFMI: Fat-Free Mass Index; FM: Fat Mass; FMI: Fat Mass Index; IMD: Index of Multiple Deprivation; OR: Odds Ratio; PA: Physical Activity; SLIC: Size and Lung function In Children; UK: United Kingdom

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Availability of data and materials
The SLIC data that support the findings of this study are available from University College London, Great Ormond Street Institute of Child Health, but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of the SLIC database administrators at UCL. Please contact JW with data requests. The governmental Index of Multiple Deprivation data are publicly available, via: https://www.gov.uk/government/collections/english-indices-of-deprivation (last accessed: March 1, 2019).

Authors' contributions
Primary data collection for the SLIC study was performed by JW and SL. The secondary data analyses were designed by LB and AR, and performed and interpreted by LB. The manuscript was written by LB, and the final version reviewed by JW, SL and AR. All authors have read and approved the manuscript.

Ethics approval and consent to participate
Ethical approval for the SLIC study was obtained from the London-Hampstead research ethics committee (REC: 10/H0720/53), while approval for the secondary data analyses was obtained from the research ethics committee at the Department of Geography, University of Cambridge, UK (Ethics Assessment Number 698). Parental written consent and child verbal assent were obtained prior to assessments for all participants to the SLIC study.

Consent for publication
Not Applicable.

Competing interests
The authors declare that they have no competing interests.

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Appendix 4 – Article Bosch et al. 2020; PLoS One

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RESEARCH ARTICLE

Associations of the objective built environment along the route to school with children's modes of commuting: A multilevel modelling analysis (the SLIC study)

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Abstract

As active commuting levels continue to decline among primary schoolchildren, evidence about which built environmental characteristics influence walking or cycling to school remains inconclusive and is strongly context-dependent. This study aimed to identify the objective built environmental drivers of, and barriers to, active commuting to school for a multi-ethnic sample of 1,889 healthy primary schoolchildren (aged 5–11) in London, UK. Using cross-sectional multilevel ordered logistic regression modelling, supported by the spatial exploration of built environmental characteristics through cartography, the objective built environment was shown to be strongly implicated in children's commuting behaviour. In line with earlier research, proximity to school emerged as the prime variable associated with the choice for active commuting. However, other elements of the urban form were also significantly associated with children's use of active or passive modes of transport. High levels of accidents, crime and air pollution along the route to school were independently correlated with a lower likelihood of children walking or cycling to school. Higher average and minimum walkability and higher average densities of convenience stores along the way were independently linked to higher odds of active commuting. The significance of the relations for crime, air pollution and walkability disappeared in the fully-adjusted model including all built environmental variables. In contrast, relationships with proximity, traffic danger and the food environment were maintained in this comprehensive model. Black children, pupils with obesity, younger participants and those from high socioeconomic families were less likely to actively commute to school. There is thus a particular need to ensure that roads with high volumes of actively commuting children are kept safe and clean, and children's exposure to unhealthy food options along the way is limited. Moreover, as short commuting distances are strongly correlated with walking or cycling, providing high-quality education near residential areas might incite active transport to school.

Data Availability Statement: All relevant data are within the manuscript and its Supporting Information files.

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Abbreviations: BAME, Black, Asian and Minority Ethnic; FEAT, Food Environment Assessment Tool; FMI, Fat Mass Index; LSOA, Lower Super Output Area; SLIC, Size and Lung function In Children; WHO, World Health Organization.

Introduction

1.1 Active commuting, physical activity and health

Children's physical activity levels are dwindling in the UK and around the world [1]. Simultaneously, rates of childhood obesity continue to rise globally [2]. This double issue is particularly problematic in urban environments. In London, for example, only a quarter of children meet current physical activity guidelines [3]. Moreover, by the end of primary school, nearly forty percent of children are overweight or obese [4]. Increased physical activity is linked to a wide range of physical and mental health benefits [5,6]. To maintain and improve child health, the World Health Organization (WHO) recommends at least 60 daily minutes of moderate-to-vigorous physical activity for children aged 5–17 [7]. Active school commuting holds great potential as a source of daily physical activity for children, and has been associated with higher activity levels throughout the day [8,9]. Whilst evidence is still scarce, active commuting has also been linked to lower fat mass in children [10]. However, active mobility interventions tend to have small effect sizes [11]. It is therefore important to identify drivers of, and barriers to, children's propensity to walk, scoot or cycle to school, to devise policy interventions that can raise levels of active mobility.

1.2 Active commuting and the built environment

Due to their higher physical activity levels and rapid development, children are strongly influenced by the variety of built environments to which they are exposed [12]. The built environment is also heavily implicated in transport-related decisions [13]. Six objectively measurable built environmental variables are frequently suggested to influence children's commuting mode choices, or require further clarification: school proximity; traffic risk; personal risk; air pollution; walkability; and the food environment. The first of these variables, proximity, has been most consistently associated with children's mode of commuting [13].

Secondly, parental and child concerns about traffic safety may impact commuting decisions, as may personal safety risks, the third variable. Risk perceptions, particularly those of parents, are increasingly linked to children's physical activity and active travel [9, 14]. However, consistent evidence is lacking on whether objective accident and crime rates significantly influence commuting decisions [9].

Next, while the adverse consequences of air pollution on population health have been frequently reported [15], its effect on child physical activity is largely unknown, especially in a European context [16]. Exploring this association is crucial, as UK research highlights that children walking to school are exposed to higher pollution levels than passive commuters [17].

To capture the joint impact of built environmental characteristics on stimulating active transport, the concept of 'walkability' has been introduced [18]. Conventionally, information on land use mix, street connectivity and residential density is combined in a composite index [19]. Walkability has been shown to be a consistent correlate of adult walking and cycling [20]. However, evidence for children is much sparser [12, 21].

Finally, the food environment is widely recognized to be an important driver of weight gain [22]. Commuters are directly exposed to the foodscapes in their surroundings [23], and this has been preliminarily linked to children's activity levels [24]. The potential link between the food environment and children's transport to school should therefore be explored.

1.3 Study aim

The present research aimed to study the associations of the complex web of built environmental characteristics with children's mode of commuting to school for a multi-ethnic urban sample of UK primary schoolchildren. It achieved this aim through the combination of multilevel modelling analyses and cartography.

Materials and methods

2.1 Sample

Cross-sectional analyses were performed on data collected between December 2010 and June 2013 for 1,889 primary schoolchildren in good health aged 5–11, attending thirteen schools in London. These children participated in the Size and Lung function In Children (SLIC) study, carried out at the Great Ormond Street Institute of Child Health, University College London, UK [25]. 53.7% of this sample of SLIC children were female. About a quarter were aged five to six (24.6%), 38.1% were seven to eight years old, and the remaining 37.3% were aged nine to eleven. The purposeful sampling of schools based on their diverging geographical location, education performance and ethnic mix guaranteed the inclusion of a diverse, representative sample of London primary schoolchildren. Further details are provided elsewhere [25, 26]. Ethical approval for the SLIC study was obtained from the London-Hampstead research ethics committee (REC: 10/H0720/53). Parental written consent and child verbal assent were obtained prior to assessments for all participants to the SLIC study. Approval for secondary data analyses was obtained from the research ethics committee at the Department of Geography, University of Cambridge, UK (Ethics Assessment Number 698).

2.2 Variables

2.2.1 Response variable–mode of commuting. Using a questionnaire, SLIC children and their parents/guardians were independently asked about the dominant mode of school transport [25,26]. Their response was classified as 'active commuting' if the child predominantly walked or cycled. Where car, bus or underground were dominant, this was labelled 'passive commuting'. If both active and passive modes of transport contributed significantly, this was classified as 'mixed commuting'. Where parent and child responses differed, this disagreement was interpreted as an indication of variable or mixed commuting. Hence, this group was added to the 'mixed' category.

2.2.2 Predictors–built environmental data. Values for the six built environmental variable values described above were calculated along the shortest route between the place of residence of each SLIC child and the school she or he attended, using ArcMap 10.5.1 (ESRI 2017, Redlands, CA, USA). The location of the SLIC child's home, obtained through the parental questionnaire, was included as the centroid of their 2011 Output Area of residence. Output Areas are the smallest spatial units meeting the confidentiality threshold (containing minimum 40 households) for which UK census data are available [27]. With 95% of Output Areas containing between 79 and 189 households [27], their centroids can be assumed to reasonably approximate the actual location of SLIC children's homes. Distance to school was calculated along the shortest route (in metres) between this centroid and the school the child attended. Commuting distances were subdivided into four categories: $<$500.0 metres, 500.0–999.9 metres, 1,000.0–1,499.9 metres and $\geq$1,500.0 metres. 1,500 metres is often considered to be the maximum walkable distance to school [28].

For the other built environmental variables, two values were calculated. On the one hand, the average value across all administrative units traversed by children along the shortest way to school was computed. On the other, the most extreme, 'worst-case' value encountered by children during their commute was included, often assumed to be more impactful in transport decisions [29].

Traffic risk was measured by the 2011 rates of 'accidents with injury' in the Lower Super Output Areas (LSOAs) SLIC children crossed along their way to school. LSOAs were selected as they balance the detail provided by smaller spatial units with the statistical reliability of larger, more populated areas. Accident data were collected by the UK Department for Transport [30] and categorized as <20.0, 20.0–39.9 or ≥40.0 accidents with injury per 10,000 inhabitants.

Personal risk was calculated using 2010/2011 crime rates, based on the total number of notifiable offences in the LSOAs children passed. These data were collected by SafeStats London per financial year, and made available in the 2011 London LSOA Atlas [31]. They are subdivided into three dimensionless categories: <90.0, 90.0–109.9 and ≥110.0.

The Combined Emissions Index available in the same database was used as the measure for air pollution [31]. Nitrogen Oxide, Nitrogen Dioxide and Particulate Matter (PM_{10}) concentrations were combined to assign an overall air quality score to each LSOA. As pollutant concentrations are closely related to local motorized vehicle exhaust [32], this also served as a proxy of traffic density. This dimensionless index was subdivided into three categories: <90.0, 90.0–109.9 and ≥110.0.

Stockton and colleagues [19] computed a walkability index for London Output Areas, combining residential dwelling density, density of three- or more-way junctions and land use mix. The walkability quintile scores for the 2011 Output Areas were selected as the walkability measure.

The food environment was included as the categorized density of convenience stores in a one-mile radius around the postcodes the child crossed during the commute (≤20, 21–50, 51–80 or >80 stores/mile^2). These data were collected as part of the Food Environment Assessment Tool (FEAT) project [33]. The earliest available data, from 2014, were used.

2.2.3 Potential confounders. Information on children's age (in years), sex and school attended was collected during school visits. Ethnicity data were collected via the parental questionnaire [25, 26]. Children were assigned to one of three ethnic groups: black (African/Caribbean ancestry), South Asian (ancestry from the Indian subcontinent) or white/other (European/other/mixed ancestry). Body composition might be associated with children's commuting decisions, although the directionality of relations cannot be causally established in cross-sectional models. Sample-specific percentiles of children's age- and sex-adjusted Fat Mass Index (FMI) were calculated using data on fat mass (estimated through bio-electrical impedance analysis using standing instrumentation; Tanita BC418, Tanita Corporation, UK) adjusting for the square of height. As fat mass data were skewed, these were natural log-transformed prior to the calculation of z-scores. Similar to Centers for Disease Control and Prevention guidelines [34], SLIC children were assigned to one of four weight status categories, using the 5th, 85th and 95th percentiles as class boundaries (underweight, normal weight, overweight or obese). Data on family socioeconomic status were also gathered via the questionnaire [25]. The three included variables are: Family Affluence Scale category (low, intermediate or high), whether or not the child received free school lunches, and car ownership (zero to two cars). Finally, neighbourhood deprivation was captured by the 2010 Index of Multiple Deprivation score for the postcode of residence (categorized as low, intermediate or high deprivation). Detailed information on these measures has been published previously [10].

2.3 Analyses

Data visualisation sheds light on the spatial distribution of potential drivers to, and barriers of, children's active commuting across London. Hence, firstly, the six built environmental characteristics and two potential confounders for which London-wide data were available, ethnicity and deprivation, were mapped in ArcMap 10.5.1. For convenience store density, accurate data were only provided for the postcode areas where SLIC children resided. For other areas, Borough-level data are shown. 32 Boroughs, or local authorities, make up Greater London, with an average population of around 255,000 inhabitants at the time of the 2011 population census [35]. As no London-wide FMI data were available, this variable could not be included in the cartographic analyses.

Statistical analyses were carried out in Stata 15 (StataCorp 2017, College Station, TX, USA). Performing multilevel modelling analysis on two levels avoids violating the assumption of independence of observations due to the nested data structure [36, 37]. The first level captures individual and family characteristics through the inclusion of children's age, sex, ethnicity and family and neighbourhood socioeconomic status. The second level then corrects for the higher likelihood of similar home and school environments of children attending the same school by grouping them by school. The response variable, mode of commuting, can be interpreted as an ordinal categorical variable, whose outcomes can be ranked from passive commuting, involving the least physical activity, through mixed commuting, to active commuting, entailing the highest activity levels. This resulted in the design of a mixed-effects two-level ordered logistic regression model [38].

Two sets of models were designed. Firstly, associations between the average and extreme value for each individual built environmental characteristic and SLIC children's likelihood of active commuting to school are presented, fully corrected for potential confounders. Secondly, the results of a comprehensive, fully-adjusted model including all six built environmental measures are shown and discussed. The choice to include either the average or extreme value for each built environmental variable was made depending on the strength and significance of their independent associations with commuting in the individual models.

In practice, these models were estimated using Stata's mixed-effects ordered logistic regression ('meologit') command function. Children's mode of commuting was the ordinal response variable in all models. The built environmental variables were included as first-level explanatory variables, individually in the first set of models and combined in the second set, together with the full range of potential confounders. Following their categorization, all explanatory built environmental variables were treated as factor variables in the models (using the 'i.' command in Stata), as were all potential confounders with exception of age, the latter being considered a continuous variable. The lowest category for each built environmental characteristic was consistently set as reference. For potential confounders, the selected reference categories were female sex, white/other ethnicity, normal fat mass, low family affluence, no receipt of free school lunches, no family car ownership and low Index of Multiple Deprivation. On the second level of the multilevel analyses, the identification number of the schools was then included in all models as the group variable.

Results are shown as Odds Ratios with 95% Confidence Intervals for active commuting in comparison to mixed or passive commuting. Statistical significance was set at $p<0.05$.

Results

Cartography and descriptive statistics

The sample data are made available in *S1 Table*. SLIC children resided primarily in the Borough where their school was located, mainly in the northern part of London (*Fig 1*). Three schools were in the Boroughs of Newham and Enfield, two in Southwark and Brent, and one each in Haringey, Hackney and Harrow. 46.7% of children predominantly commuted actively to school, and 31.7% used mainly passive means of transportation (*Table 1*). 21.6% belonged

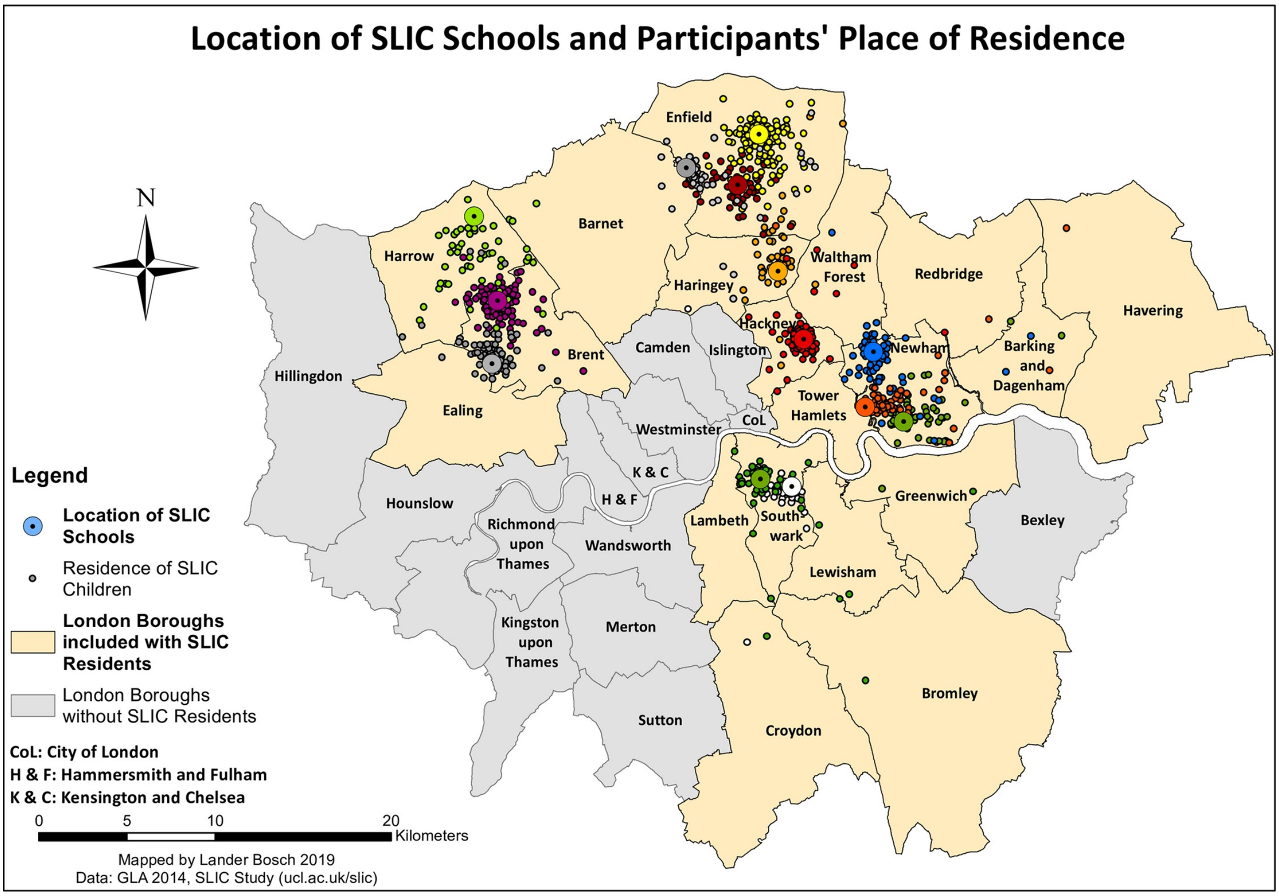

Fig 1. Proximity to school, data © see acknowledgements.

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to the mixed/disagreement category. One of ten children resided within 500 metres of school, while for 41.7% of children, the shortest distance to school was over 1,500 metres.

Traffic risk varied strongly across London, though consistently high accident rates were found in the city centre (*Fig 2*). Children, especially those with longer commuting distances, were thus likely to be exposed to strongly diverging degrees of risk along the way. The descriptive statistics corroborate this observation: the average traffic risk along the route fell in the lowest category for 31.3% of children, compared to 18.9% in the highest category. However, 62.5% of participants were confronted with at least one LSOA segment with the highest risk.

Personal risk in London showed a clear spatial pattern (*Fig 3*). Crime rates were high along quasi-perpendicular axes running from west to east and north to south, converging in Central London. SLIC children residing and attending school towards the edges of the city (in Enfield and Harrow) were confronted with lower personal risk than those closer to the centre. 48.7% were exposed to low average levels of crime along the commuting route. However, over two-thirds of pupils (69.1%) passed through at least one LSOA in the highest crime rate category.

Air pollution showed a distinct radial pattern (*Fig 4*), with the highest concentrations of air-borne toxins found in the central Boroughs. Local pollution hotspots elsewhere, often following linear patterns, can be linked to major traffic arteries or, in West London, the presence of

Table 1. Commuting and built environmental measures for the sample of SLIC children in the current study.

Variable	Number of SLIC children	Percentage (%)
Dominant mode of commuting		
Active	883	46.7
Passive	598	31.7
Mixed & Disagreement	408	21.6
Proximity to School–Network (m)		
< 500.0	190	10.1
500.0–999.9	457	24.2
1,000.0–1,499.9	454	24.0
≥ 1,500.0	788	41.7
Average Traffic Risk along Route		
Average accident rate per 10^4 inhabitants crossed		
<20.0	591	31.3
20.0–39.9	940	49.8
≥ 40.0	358	18.9
Maximum Traffic Risk along Route		
Highest accident rate per 10^4 inhabitants crossed		
<20.0	151	8.0
20.0–39.9	557	29.5
≥ 40.0	1 181	62.5
Average Personal Risk along Route		
Average crime rate crossed		
<90.0	919	48.7
90.0–109.9	193	10.2
≥ 110.0	777	41.1
Maximum Personal Risk along Route		
Highest crime rate crossed		
<90.0	423	22.4
90.0–109.9	161	8.5
≥ 110.0	1 305	69.1
Average Air Pollution along Route		
Average Combined Emission Index crossed		
<90.0	626	33.1
90.0–109.9	975	51.6
≥ 110.0	288	15.3
Maximum Air Pollution along Route		
Highest Combined Emission Index crossed		
<90.0	212	11.2
90.0–109.9	983	52.0
≥ 110.0	694	36.8
Average Walkability along Route		
Average quintile crossed		
1 (least walkable)	182	9.6
2	545	28.9
3	544	28.8
4	526	27.8
5 (Most walkable)	92	4.9
Minimum Walkability along Route		

(*Continued*)

Table 1. (Continued)

Variable	Number of SLIC children	Percentage (%)
Lowest quintile crossed		
1 (least walkable)	1 226	64.9
2	356	18.8
3	221	11.7
4	79	4.2
5 (Most walkable)	7	0.4
Average Food Environment along Route		
Average convenience stores/mile^2 crossed		
≤20	78	4.1
21–50	1 005	53.2
51–80	226	12.0
> 80	580	30.7
Maximum Food Environment along Route		
Highest convenience stores/mile^2 crossed		
≤20	32	1.7
21–50	761	40.3
51–80	432	22.9
> 80	664	35.1

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Heathrow Airport. 15.3% of children were faced with average pollution levels in the highest category during their commute. However, over a third of pupils (36.8%) were confronted with a maximum Combined Emission Index score of over 110 in at least one LSOA along the route.

Walkability also reduced from the centre of the city to the outskirts (*Fig 5*), with local hotspots in the denser urban cores of Outer London Boroughs. Hence, walkability levels around SLIC participants' homes and schools in Newham, Southwark and Hackney were generally higher than those in Haringey, Brent, Enfield or Harrow. 85.5% of children commuted along roads with an average Walkability Index score in the intermediate second, third or fourth quintiles. However, 64.9% had to cross at least one Output Area in the lowest quintile.

The spatial distribution of convenience stores showed a patchy pattern. Densities were generally highest towards Central London, with hotspots of these outlets across the city (*Fig 6*). SLIC schools and pupils residing in Southwark, Hackney, Newham and Haringey were surrounded by highest convenience stores densities. For only 4.1% of children, the average density on the way to school fell in the lowest category (≤20 stores/mile^2), versus nearly a third with over 80 stores/mile^2. 35.1% were confronted with these high densities at specific points of their commute.

Further descriptive statistics relating to confounders are provided in *S2 Table*. Just over a quarter of SLIC children were black, and a similar share were South Asian. The black, Asian and minority ethnic (BAME) population was particularly well-represented in west and northwest London, where the SLIC population was predominantly South Asian, and in the south, east and north-east, where SLIC children from minority backgrounds were predominantly black (*Fig 7*). 9.1% and 6.1% of participants were classified as having overweight or obesity based on their within-population FMI score, respectively. About two-thirds of SLIC families had intermediate affluence levels, and a similar share did not receive free school lunches. SLIC children in the northern Boroughs of Harrow and Enfield were more likely to belong to more affluent families (*Fig 8*). A quarter of families did not own a car. Deprivation followed a similar

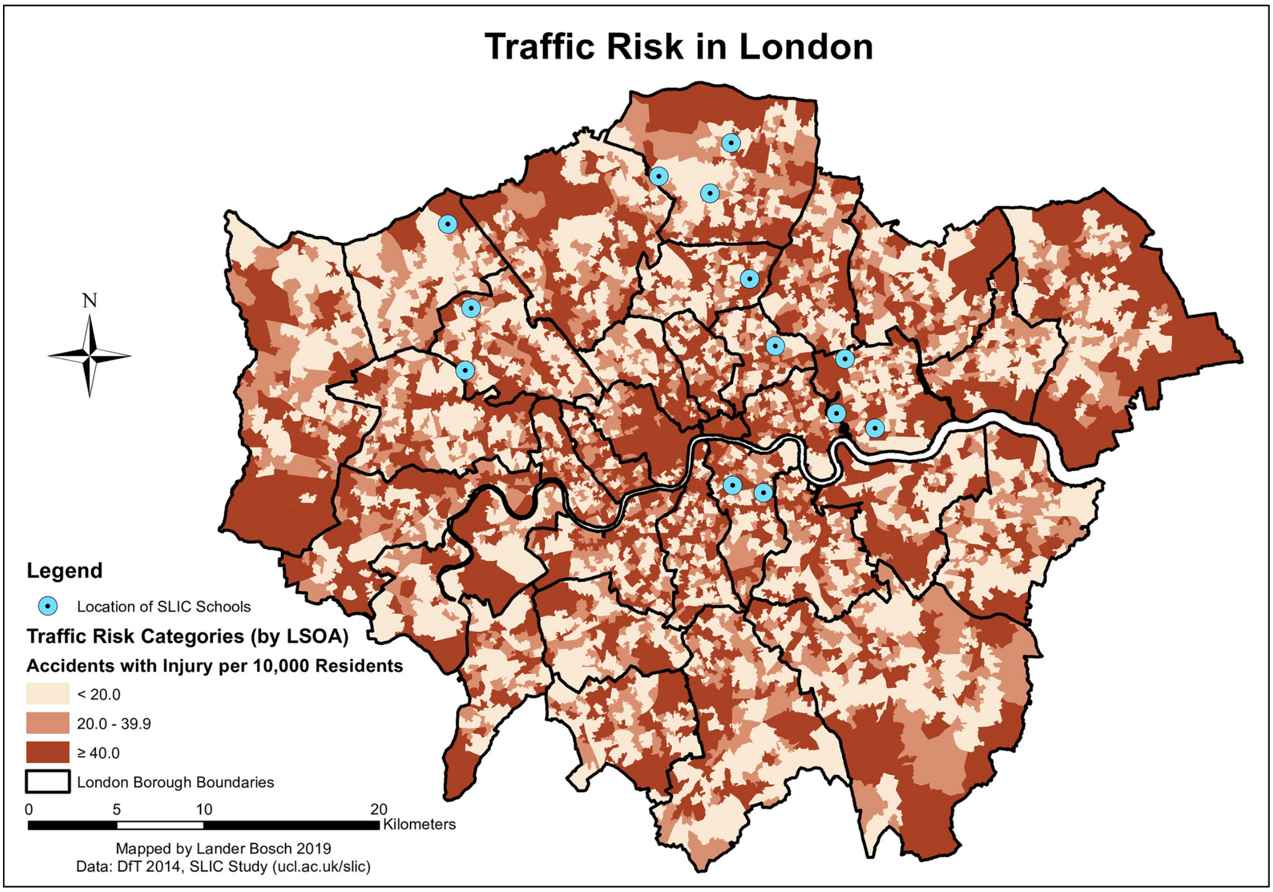

Fig 2. Traffic risk in London, data © see acknowledgements.

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spatial pattern to crime rates (*Fig 8*). 52.1% of SLIC children resided in LSOAs belonging to the lowest two deprivation quintiles.

Multilevel models linking built environmental characteristics and commuting to school

The results of the multilevel models assessing the paired associations between each of the six built environmental characteristics individually and SLIC children's mode of commuting to school are shown in *Table 2*. These models were corrected for individual characteristics and family and neighbourhood socioeconomic status, and the associations described remained unchanged in models excluding FMI.

Children living further away from school had significantly lower odds of actively commuting to school compared to those residing within 500 metres. This inverse relationship intensified as commuting distance increased. Both average and extreme rates of traffic accidents along the route to school were significantly associated with SLIC children's commuting mode choices. Participants exposed to higher road risk were significantly less likely to commute actively to school, an effect which became stronger as danger increased. SLIC children who

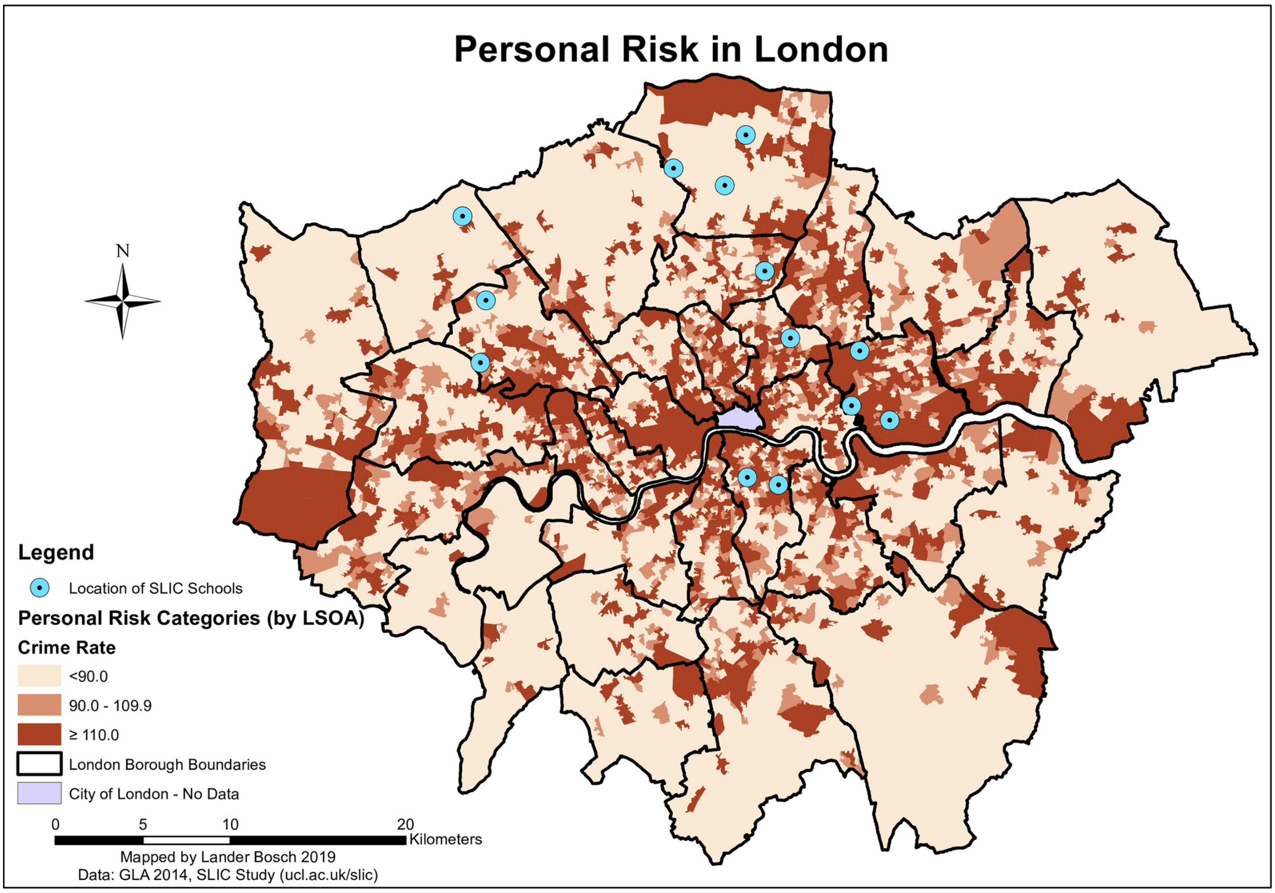

Fig 3. Personal risk in London, data © see acknowledgements.

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needed to pass through an LSOA with higher extreme crime rates were significantly less likely to actively commute to school. Again, the effect size increased as crime rates rose. No significant associations were found for average personal risk.

In terms of air quality, only maximum pollution levels were significant. Children confronted with higher maxima of airborne pollutant concentrations were less likely to use active modes of transport. Children with the most walkable commutes on average were significantly more likely to walk or cycle to school compared to participants with the least walkable commuting trajectories. Similar observations could be made for walkability extremes, except for the fifth quintile. Finally, an average convenience store density of over 50 outlets/mile^2 along the shortest route to school was associated with significantly higher active commuting odds in comparison to a route with the lowest average density. No such associations were found for extreme densities.

Given their significant associations with commuting choices, the extremes of traffic risk, personal risk, air pollution and walkability were retained in the fully corrected model including all built environmental variables and potential confounders. For the food environment, the relation with average convenience store density was stronger. Hence, this average measure was selected. *Table 3* presents the resulting associations.

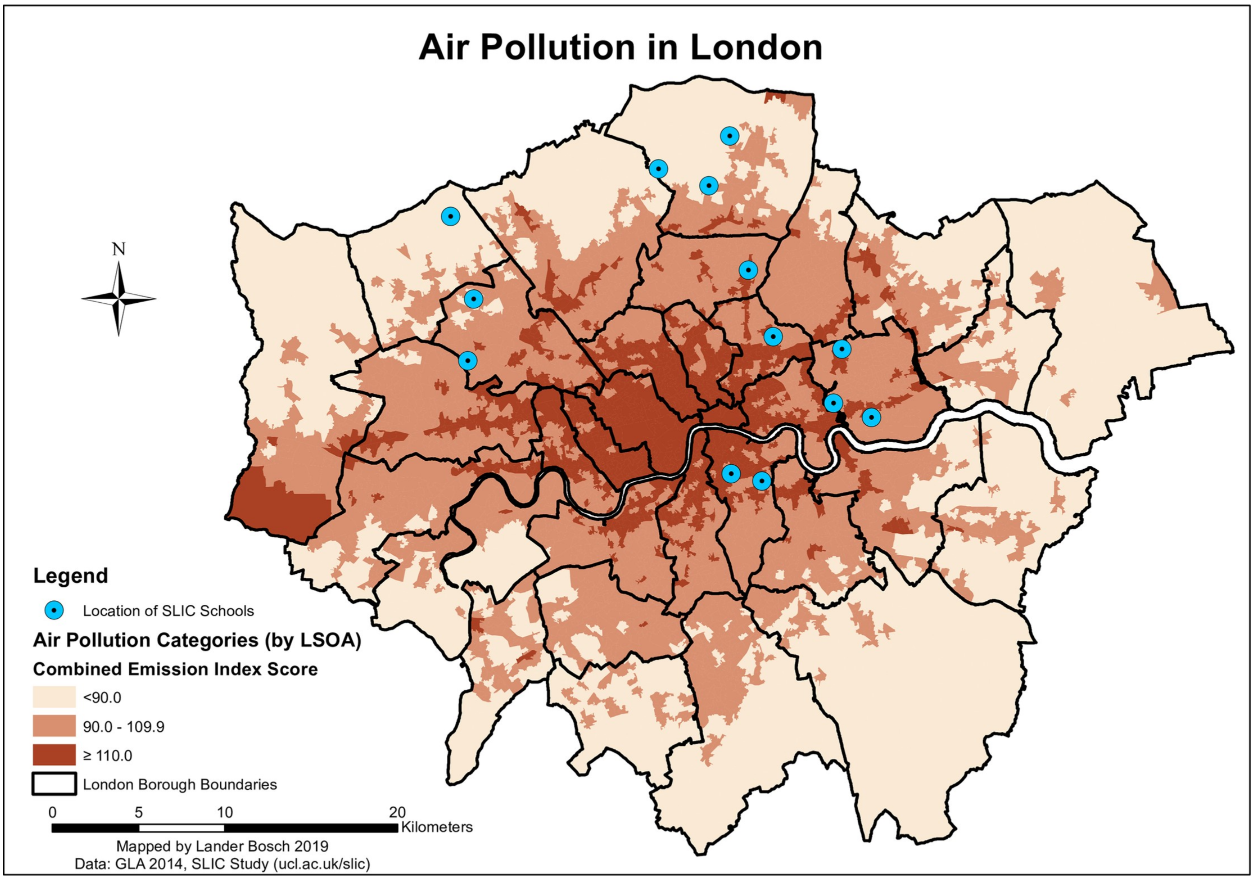

Fig 4. Air pollution in London, data © see acknowledgements.

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Three variables retained significant associations with commuting mode choices. First, SLIC participants residing further away from school had lower odds of walking or cycling to school. This proximity effect became stronger as distance increased. Secondly, in comparison to children exposed to the lowest accident rates, those confronted with intermediate traffic risk were less likely to actively commute. Finally, children exposed to an average density of 51–80 convenience stores/mile^2 had over three times the odds of commuting actively compared to their peers surrounded by the lowest food outlet densities.

Looking at potential confounders, no significant sex differences emerged. Older children were increasingly likely to use active modes of school transport. Compared to the white/other group, black SLIC children had about half the odds of choosing active commuting modes. No such relation emerged for the South Asian group. In comparison to children with normal fat mass, children in the obese category had significantly lower odds of actively commuting. Participants from highly affluent families were significantly less likely to walk or cycle to school in comparison to those from a low-affluence family. Car ownership, and particularly a second car, significantly reduced the odds ratios for active commuting. No significant relation was obtained for neighbourhood deprivation.

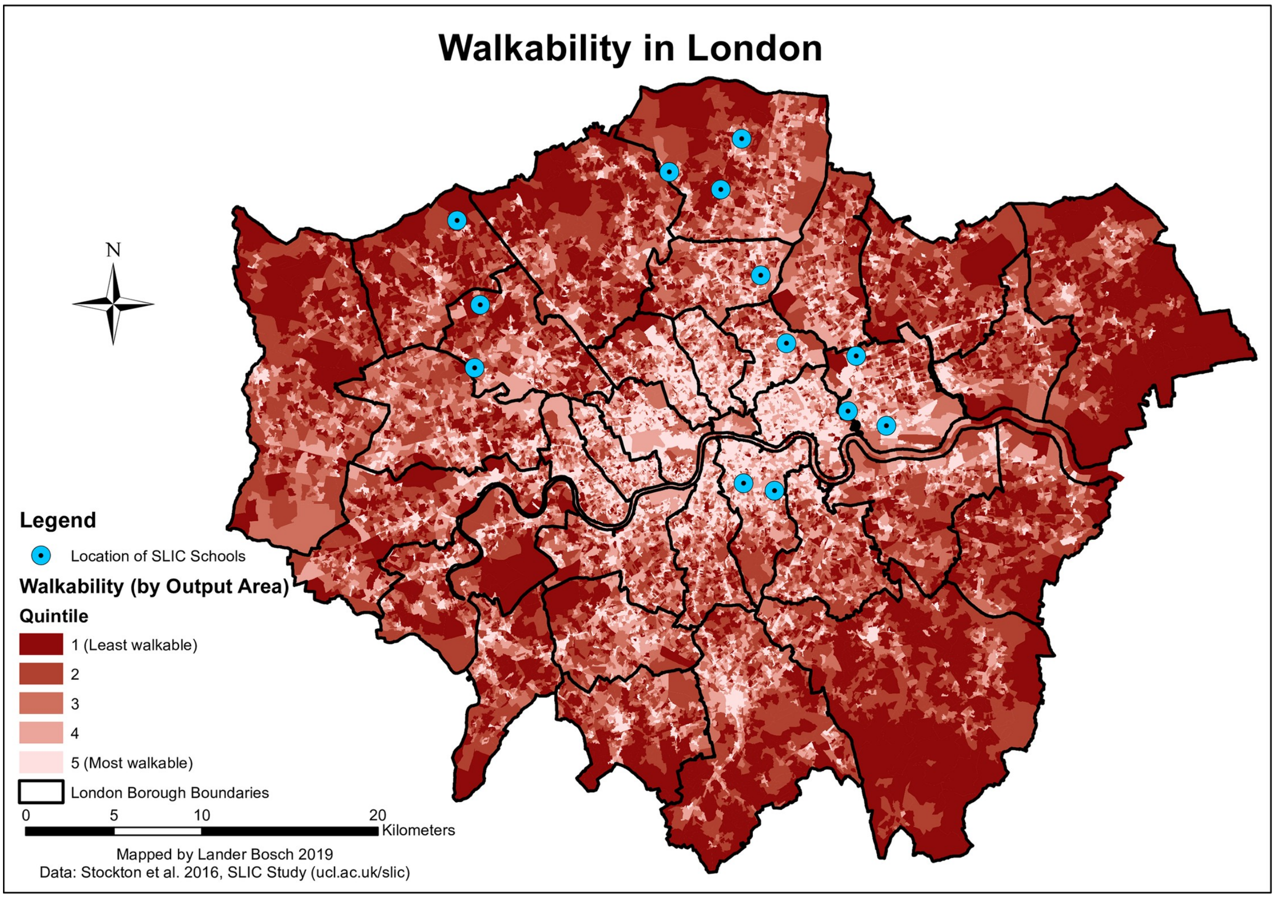

Fig 5. Walkability in London, data © see acknowledgements.

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Discussion

This study investigated the associations between objective built environmental characteristics and commuting mode choices for a multi-ethnic sample of UK children participating in the SLIC study. To our knowledge, it is the first to assess the associations of this wide diversity of objective built environmental variables with transport decisions for urban schoolchildren in the UK throughout primary school.

Associations between built environmental characteristics and modes of commuting to school

Distance to school was consistently and negatively associated with active commuting to school for SLIC children, both in the individual and comprehensive models and irrespective of potential confounders or mediators. The associations were stronger for longer commutes. Prior evidence points to the importance of a limited distance to school in the decision to walk or cycle [13, 39, 40]. The odds ratios for active versus passive or mixed commuting for pupils residing over 1,500 metres from school were just over one-tenth of those living closest to school. Hence the criterion distance for walking to school for children, set around 1.5 kilometres [28, 41],

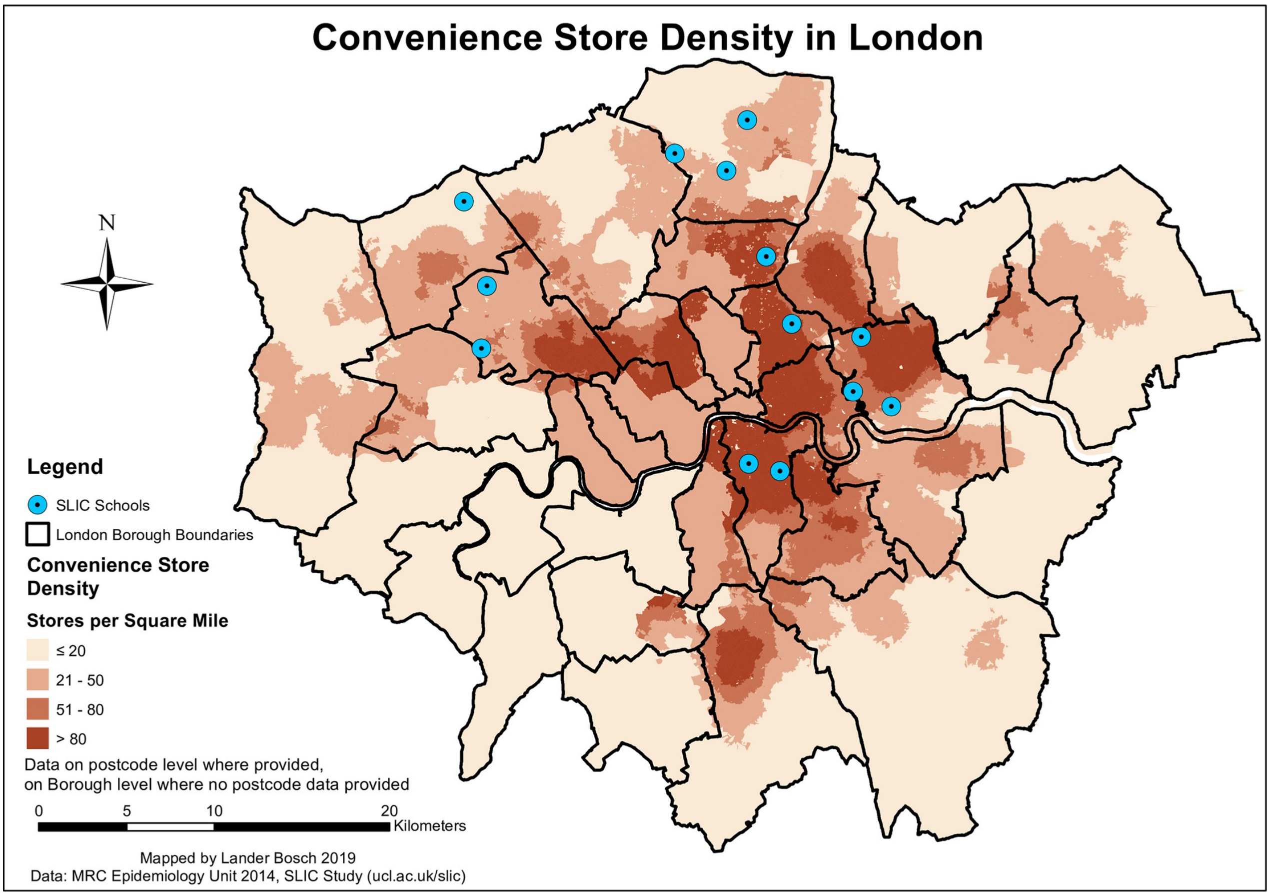

Fig 6. Convenience store density in London, data © see acknowledgements.

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should be interpreted as a hard barrier to active commuting for this sample of London schoolchildren. Longer distances to school are not only related to longer travel times, but also to increased practical constraints and safety concerns [42]. The cartography demonstrated that longer commutes increase the likelihood that children will encounter disadvantageous environmental conditions along the way. The strategic location of schools within the walkable catchment area of neighbourhoods with a high population share of schoolchildren might thus increase levels of active commuting [41, 42]. Moreover, this might reduce the reliance on free public transport provided to pupils deemed to live too far from the nearest suitable school or commuting along unsafe walking routes. Currently, boundaries for free school transport are set at 3.2 kilometres for children aged 8 or under, and 4.8 kilometres for those aged 8–16 [43].

SLIC children were less likely to actively commute if they crossed unsafe neighbourhoods. In the individual models, both average and extreme accident risk showed significant associations, as did extreme crime rates. The association between unsafe traffic conditions and children's lower odds of active commuting remained significant in the comprehensive model for the group encountering a maximum accident level between 20 and 40 per 10,000 inhabitants. This link between higher exposure to more hazardous road environments and a lower

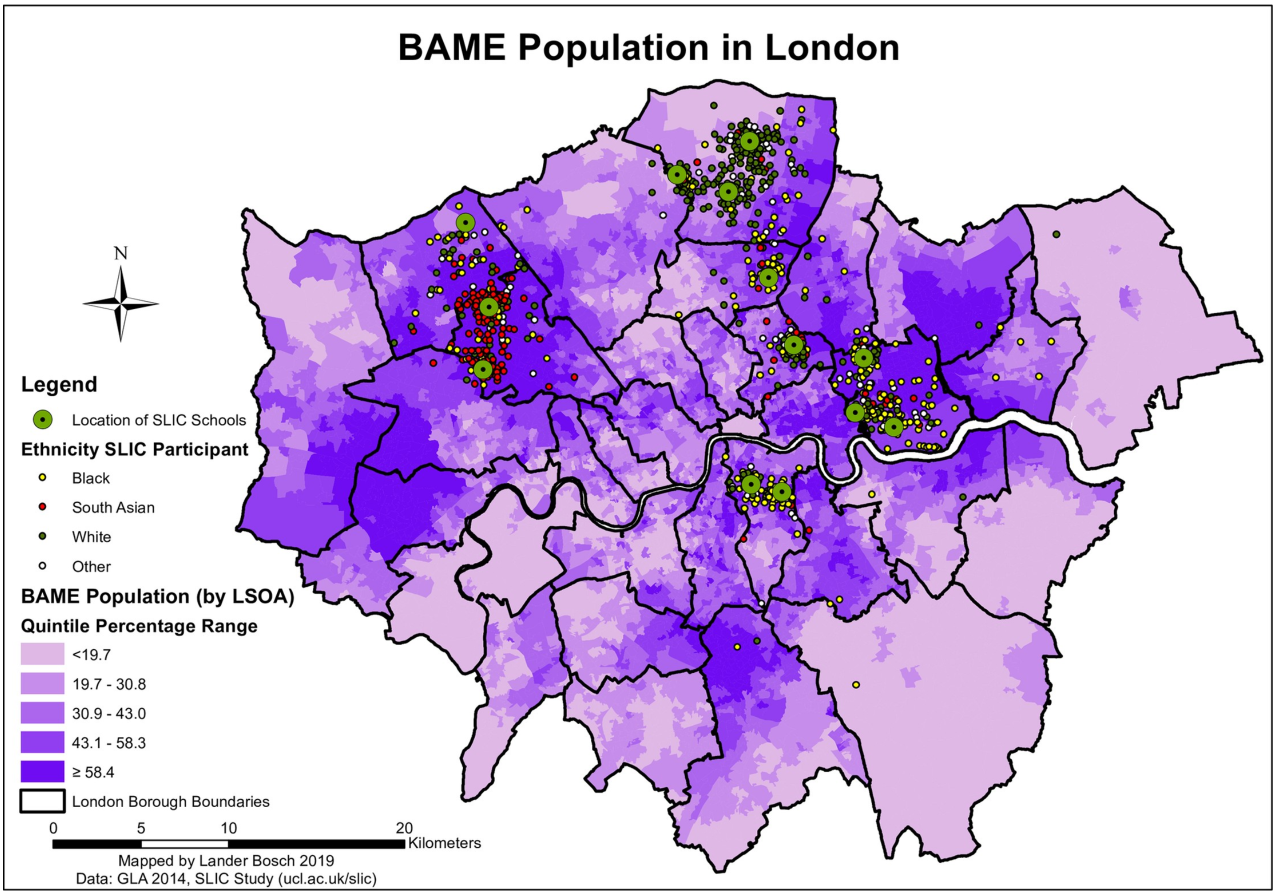

Fig 7. BAME population in London, data © see acknowledgements.

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likelihood to walk or cycle to school supports earlier research in a Dutch context [44]. It also shows that the 'worst case scenario' along part of the route may act as a particularly strong deterrent to active travel [29]. As actively commuting children are particularly vulnerable road users [17, 45], the need for interventions to reduce the risk of traffic injuries is pressing. The traffic safety map showed that hotspots of risk occur across the city, making this a London-wide concern. Prior research has highlighted that (primarily parental) safety perceptions can be decisive in determining children's activity [46]. However, our findings indicate that objective safety can also be linked to commuting decisions, or, that parental perceptions closely match objective risks. While providing an objectively safe commuting environment is thus pivotal, this might not automatically result in higher levels of active transport if it is not followed by an immediate or longer-term increase in perceived safety [9].

In the individual model, highs of pollutant concentrations were also found to significantly reduce the odds for children to use active transport. Children thus appeared to be deterred by unhealthy levels of air pollution and, as a proxy, of dense traffic en route to school. The maps showed these high concentrations were primarily found in Central London and along major traffic arteries. This finding was not retained in the comprehensive model, perhaps due to the predominance of more immediate road risks over air quality concerns. Nonetheless,

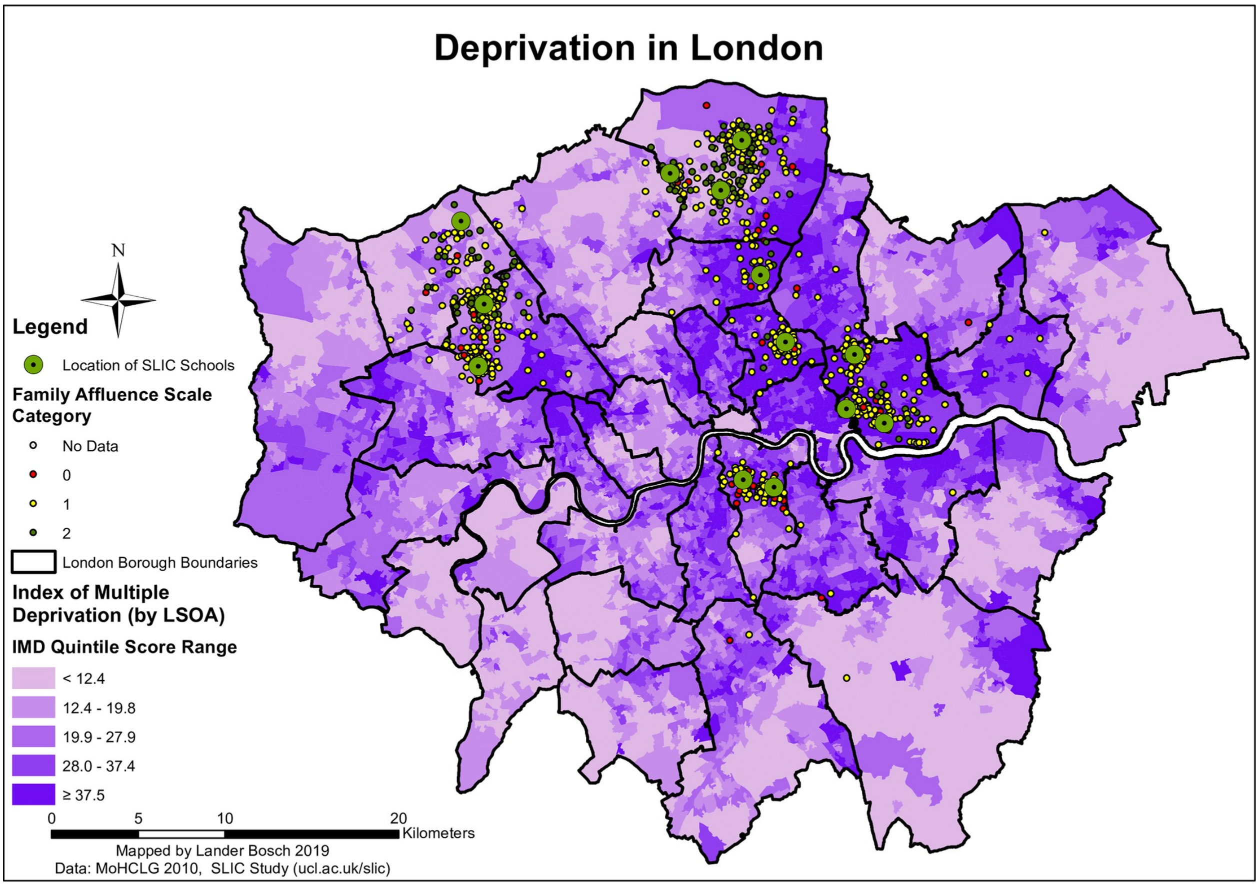

Fig 8. Deprivation in London, data © see acknowledgements.

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addressing high levels of air pollution is vital, given the disproportional exposure of active commuters to airborne toxins [17].

The results also add to the hitherto equivocal evidence for walkability [12]. Similar to findings for adults, our results for the individual model underline that the combination of high residential density, street connectivity and land use mix, highest in Central London, could stimulate children's physical activity. A similar, positive association was found in three out of five cases elsewhere in Europe [47]. However, the lack of significant associations in the comprehensive model shows that other built environmental characteristics appear to be more influential.

While the food environment is heavily implicated in the childhood obesity epidemic, its potential role in shaping behavioural habits and generating mobility bias has only recently been conceptualized [24, 48]. Here, the individual multilevel model revealed that SLIC children surrounded by 50 convenience stores/mile^2 or more on average had higher odds of active commuting than those living in areas with the lowest outlet densities. This significant association was retained in the comprehensive model for participants encountering an average of 51–80 convenience stores/mile^2 during the school commute. These children, mainly residing

Table 2. Associations between individual built environmental measures and SLIC children's active commuting[a].

Variable	Odds Ratio [Confidence interval]	p-value
Proximity		
Shortest route distance to school (m)—reference: <500.0		
500.0–999.9	0.616 [0.385–0.986]	.043*
1,000.0–1,499.9	0.301 [0.188–0.482]	< .001***
≥ 1,500.0	0.115 [0.073–0.182]	< .001***
Average Traffic Risk along Route		
Average accident rate per 10^4 inhabitants crossed—reference: <20.0		
20.0–39.9	0.636 [0.501–0.807]	< .001***
≥ 40.0	0.586 [0.397–0.863]	.007**
Maximum Traffic Risk along Route		
Highest accident rate per 10^4 inhabitants crossed—reference: <20.0		
20.0–39.9	0.481 [0.317–0.729]	.001**
≥ 40.0	0.315 [0.216–0.459]	< .001***
Average Personal Risk along Route		
Average crime rate crossed—reference: <90.0		
90.0–109.9	0.832 [0.553–1.250]	.375
≥ 110.0	1.247 [0.824–1.887]	.296
Maximum Personal Risk along Route		
Highest crime rate crossed—reference: <90.0		
90.0–109.9	0.592 [0.387–0.906]	.016*
≥ 110.0	0.446 [0.330–0.602]	< .001**
Average Air Pollution along Route		
Average Combined Emission Index crossed—reference: <90.0		
90.0–109.9	1.218 [0.848–1.750]	.286
≥ 110.0	1.393 [0.816–2.377]	.224
Maximum Air Pollution along Route		
Highest Combined Emission Index crossed—reference: <90.0		
90.0–109.9	0.600 [0.402–0.894]	.012*
≥ 110.0	0.522 [0.315–0.867]	.012*
Average Walkability along Route		
Average quintile crossed—reference: 1 (least walkable)		
2	1.019 [0.677–1.534]	.928
3	1.037 [0.636–1.691]	.884
4	1.429 [0.803–2.543]	.225
5 –Most walkable	2.611 [1.209–5.639]	.015*
Minimum Walkability along Route		
Lowest quintile crossed—reference: 1 (least walkable)		
2	1.682 [1.239–2.285]	.001**
3	2.082 [1.371–3.162]	.001**
4	3.994 [2.070–7.703]	< .001***
5 –Most walkable	1.296 [0.266–6.318]	.749
Average Food Environment Density along Route		
Average convenience stores/$mile^2$ crossed—reference: ≤20		
21–50	1.307 [0.663–2.578]	.440
51–80	4.755 [1.973–11.459]	.001**

(Continued)

Table 2. (Continued)

Variable	Odds Ratio [Confidence interval]	p-value
> 80	**2.813 [1.161–6.820]**	**.022***
Maximum Food Environment Density along Route		
Highest convenience stores/mile² crossed—reference: ≤20		
21–50	0.542 [0.183–1.601]	.268
51–80	0.488 [0.160–1.493]	.209
> 80	0.581 [0.176–1.923]	.374

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closer to the centre of London, were thus disproportionally exposed to unhealthy nutritional options. This association might be the consequence of an activity-inciting effect of convenience stores, acting as potential intermediate destinations during the school commute, or be caused by the strategic location of such stores in areas with high volumes of active commuters [49]. If the first interpretation is correct, then the potential reduction in actively commuting children could be compensated by offering other incentives to walk or cycle, for instance by reducing air pollution and creating safer road environments. The latter interpretation supports initiatives aimed at reducing the number of convenience stores around schools, and stimulating the healthy food options they offer [50].

Effect of demographic and socioeconomic characteristics

This study also adds to the knowledge of demographic and socioeconomic factors associated with commuting to school. No sex-difference was found. Prior research on this association has often produced conflicting results [51]. Our findings agree with previous Dutch and US studies [52], but contrast with earlier UK research suggesting boys were more likely to actively commute [53]. The latter study, however, focused specifically on independent mobility, where sex-differences might be more pronounced. Older SLIC children were significantly more likely to actively commute, in keeping with the growing evidence on this relationship across Europe, including the UK [39, 52, 54, 55].

Within our sample, black children had about half the odds of walking or cycling to school in comparison to those in the white/other group. No such difference was found for South Asian children. Earlier UK research pointed out that black African-Caribbean primary schoolchildren were more likely to travel by public transport, and tended to live further away from school than children from other ethnicities [56, 57]. Our findings show this group, predominantly residing in south, east and northeast London, was less likely to walk or cycle independent of proximity or other built environmental and socioeconomic characteristics. These areas should therefore be a prime focus of physical activity interventions. Ethnicity can play both a confounding and mediating role in this relation, as the social environment generated by ethnic residential segregation might shape physical activity behavioural choices [58].

Children in the obese category were less likely to actively commute than those with healthy fat mass levels, although the direction of this relation cannot be conclusively determined. Whilst being the most appropriate measure of adiposity, FMI is rarely used in studies relating body composition to activity. The large majority of earlier studies, predominantly using Body Mass Index and fat mass percentage, obtained conflicting evidence on this relation [8, 59].

Turning attention to socioeconomic status revealed that children from highly affluent families and families owning a car had about half the odds of commuting actively to school compared to those in the least affluent group or without access to a car, a trend widely supported throughout literature [60, 61]. This group of families mainly resided towards the northern

Table 3. Associations between built environmental characteristics, potential confounders and SLIC children's active commuting.

Variable	Wald Chi-Squared = 254.7; $p < .001$	
	Odds Ratio [95% Confidence interval]	p-value
Proximity		
Shortest route distance to school (m)—reference: <500.0		
500.0–999.9	**0.615 [0.380–0.995]**	**.047***
1,000.0–1,499.0	**0.295 [0.182–0.479]**	**< .001*** **
≥ 1,500.0	**0.117 [0.071–0.192]**	**< .001*** **
Maximum Traffic Risk along Route		
Highest accident rate per 10^4 inhabitants crossed—reference: <20.0		
20.0–39.9	**0.592 [0.370–0.946]**	**.029***
≥ 40.0	0.710 [0.418–1.207]	.206
Maximum Personal Risk along Route		
Highest crime rate crossed—reference: <90.0		
90.0–109.9	1.029 [0.603–1.755]	.916
≥ 110.0	0.861 [0.559–1.327]	.498
Maximum Air Pollution along Route		
Highest Combined Emission Index crossed—reference: <90.0		
90.0–109.9	1.121 [0.701–1.793]	.634
≥ 110.0	1.121 [0.612–2.053]	.712
Minimum Walkability along Route		
Lowest quintile crossed—reference: 1 (least walkable)		
2	1.017 [0.713–1.451]	.926
3	0.999 [0.637–1.567]	.996
4	0.964 [0.474–1.963]	.920
5 –Most walkable	1.004 [0.186–5.422]	.996
Average Food Environment Density along Route		
Average convenience stores/mile^2 crossed—reference: ≤20		
21–50	1.156 [0.557–2.398]	.697
51–80	**3.380 [1.313–8.698]**	**.012***
> 80	1.628 [0.608–4.360]	.332
Sex (reference: female)		
Male	0.973 [0.793–1.193]	.789
Age at test; years from 5 to 11	**1.089 [1.022–1.162]**	**.009****
Ethnicity (reference: white/other)		
Black	**0.539 [0.394–0.737]**	**< .001*** **
South Asian	0.817 [0.601–1.111]	.197
FMI Weight Status (reference: Normal fat mass)		
Underweight (<5th percentile)	1.114 [0.567–2.187]	.755
Overweight (85th-95th percentile)	0.846 [0.600–1.194]	.342
Obese (≥ 95th percentile)	**0.569 [0.371–0.873]**	**.010***
Family Affluence Scale (reference: low)		
Moderate	0.816 [0.539–1.235]	.336
High	**0.578 [0.356–0.936]**	**.026***
Free school lunches (reference: no)		

(*Continued*)

Table 3. (Continued)

Variable	*Wald Chi-Squared = 254.7; p < .001*	
	Odds Ratio [95% Confidence interval]	*p-value*
Yes	0.927 [0.685–1.255]	.625
Cars owned (reference: 0)		
1	**0.593 [0.443–0.795]**	**< .001*****
2	**0.464 [0.321–0.671]**	**< .001*****
IMD (reference: low)		
Intermediate	0.912 [0.651–1.275]	.589
High	0.757 [0.511–1.123]	.167
Level 2: Variance on School Level	0.276 [0.094–0.812]	

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fringes of London. Neighbourhood deprivation was not significantly associated with these children's commuting choices. Conflicting associations on the consequences of diverging deprivation levels on children's commuting emerged in prior research. Children residing and attending schools in neighbourhoods of lower socioeconomic status were found to have higher [62], mixed [63] or lower [39, 64] levels of walking and cycling to school and physical activity, depending on the research location and context. Whilst area variation is partly captured by the second level of the multilevel models, our null-findings highlight that family socioeconomic status is likely to be more decisive in shaping commuting choices. Moreover, the UK social housing policy is explicitly aimed at creating socially mixed neighbourhoods [65]. This may reduce socioeconomic residential segregation and thereby reduce the impact of small-scale neighbourhood deprivation. Finally, also here, perceptions of deprivation might be dominant.

Research implications and limitations

This research has several wider implications. Firstly, it demonstrates that the objective built environment is significantly related to commuting mode choices for this multi-ethnic sample of UK schoolchildren. The predominance of associations with proximity shows that the equal provision of high-quality education across cities might be key in inciting active school transport. Secondly, active commuters are often exposed to hazardous built environments. The associations with traffic and personal safety, air pollution and walkability demonstrate the urgent need to provide children with safe and clean commuting routes. Next, the need for healthy food environments around schools was highlighted. This might incite actively commuting children and their parents to choose healthy food if they shop during the school commute. Finally, the confounder relations demonstrated a need to target health-promoting interventions at specific groups: black children, children from high socioeconomic status backgrounds and those living in families with one or multiple cars.

While the large, multi-ethnic sample, the multilevel modelling approach and the wide variety of included built environmental variables along the route are clear strengths of this study, several limitations also need to be acknowledged. First, the cross-sectional analyses do not allow causality to be established. Next, FEAT data were only available for 2014, the year following the conclusion of SLIC data collection. While no dramatic changes are expected during this year, small inaccuracies in convenience stores densities cannot be ruled out. Third, the self-reported commuting data could not be objectively verified. Fourth, whilst a wide variety of thoroughly tested potential confounders was selected, the inclusion of all relevant individual, family or neighbourhood variables cannot be guaranteed. Moreover, the assumption was made that children follow the shortest route to school. It was impossible to account for detours or the avoidance of specific road segments which might weaken the relationships with environmental hazards. Next, information on the presence of siblings and peers, parental and school attitudes to physical activity, and distances to public transport, which could influence children's mode of commuting, was unavailable and could therefore not be accounted for. Finally, while the SLIC sample was representative of a UK inner-city population, our results only apply to this set of London schools and pupils.

Conclusion

Our research shows how objectively measurable characteristics of the London built environment can be used to predict commuting behaviour for a representative sample of primary schoolchildren participating in the SLIC study. Proximity to school is the key characteristic associated with active commuting to school. However, personal and road safety and the provision of a healthy environment in terms of food options and air pollution along the route to school also require the attention of urban planners and policymakers. Specific attention should be given to children from minority backgrounds and affluent families. Further work could now be conducted to study the impact of these factors on conscious commuting decisions.

Supporting information

S1 Table. Manuscript dataset Bosch et al.
(XLSX)

S2 Table. Descriptive statistics for the sample of SLIC children included in the current study.
(DOCX)

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Resources: Sooky Lum.

Software: Lander S. M. M. Bosch.

Supervision: Alice M. Reid.

Visualization: Lander S. M. M. Bosch.

Writing – original draft: Lander S. M. M. Bosch.

Writing – review & editing: Jonathan C. K. Wells, Sooky Lum, Alice M. Reid.

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Appendix 5 – Brent Council Report

2019

The Brent Where We Grow Up

Investigating the Built Environment of Brent Primary Schoolchildren from a Daily Physical Activity Perspective

POLICY REPORT PREPARED FOR BRENT BOROUGH COUNCIL
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Brent

UNIVERSITY OF CAMBRIDGE

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Gonville & Caius UNIVERSITY OF CAMBRIDGE

Photo: The Avenue, a busy artery through Brent with limited safe road crossings, by Author, 2019

1

THE BRENT WHERE WE GROW UP

INVESTIGATING THE BUILT ENVIRONMENT OF BRENT PRIMARY SCHOOLCHILDREN FROM A DAILY PHYSICAL ACTIVITY PERSPECTIVE

Policy report prepared for Brent Borough Council by Lander S.M.M. Bosch

ESRC & Gonville Scholar, Department of Geography, University of Cambridge

July 2019

Photo: A bus passing by fast-food stores in Preston, by Author, 2019

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FOREWORD

'London. Everyone welcome.' For those millions using the London public transport network every single day, this slogan has become a part of their daily commute. London portrays itself as an open city, a global city, an inclusive city. Nonetheless, there are clear signs that indicate not every group might be equally well-represented or made feel at home in the UK's capital.

This report is the product of an investigation into the daily life in London of one of those groups: **primary schoolchildren**. London's youngest citizens – future adults, parents, policymakers and voters – rarely feature in policy documents, and reference to their inclusion and wellbeing often serves a purely tokenistic purpose. Hence, the need to engage with and profoundly understand the reality of London children's outdoor livelihoods is fundamental. At these testing times for London and the UK at large, there is significant urgency to address the challenges presented by the physical environment to which young Londoners are directly exposed every single day. Acting on these challenges and striving to make the built environment inclusive for children might, by consequence, contribute significantly to helping London become truly welcoming for everyone.

This report takes up this challenge by **exploring the built environment** of primary schoolchildren **in the Borough of Brent**, Northwest London. Importantly, it does so by actively **including children's own voices** as knowledgeable experts of their own neighbourhood's strengths and flaws. Part of a larger, London-wide doctoral study currently being carried out at the University of Cambridge, it attempts to shed light on the relation between characteristics of children's outdoor surroundings and the way in which these form barriers to or stimulate physical activity in the public space. This report, together with the policy report produced for the London Borough of Newham, precedes the publication of the author's full doctoral thesis on the relation between the built environment, physical activity and body composition for primary schoolchildren across London, expected in the first half of 2021.

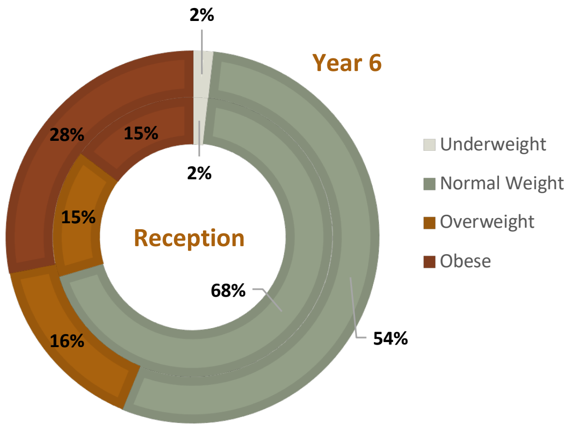
Lander Bosch, July 2019

Image: David Shrigley for TfL & Mayor of London, 2016

INTRODUCTION

London is confronted with a **double crisis** affecting its youngest citizens. On the one hand, children are **less active** than ever before. Under a quarter of London schoolchildren meet the minimum physical activity recommendations of 60 daily activity minutes of moderate-to-vigorous intensity, while over 40% do not gather more than 30 minutes every day (Townsend et al. 2015). On the other, levels of **childhood overweight and obesity** continue to rise. On average, over one out of five children of reception age across London are currently confronted with overweight or obesity. By Year 6, this has risen to nearly four out of ten being overweight or obese (London Datastore 2019). In Brent, home to nearly 34,000 children of primary school age (ONS 2018), this situation is particularly concerning. With 30% of children suffering from overweight and obesity at reception age and 44% in Year 6, it claims the top stop among London Boroughs in terms of childhood obesity (Figure 1).

Figure 1: Childhood Overweight and Obesity Levels in Brent for Primary Schoolchildren of Reception Age and in Year 6 (Data: London Datastore 2019).



Given this double epidemic of childhood inactivity and overweight and obesity, the **need for urgent action** to reverse this situation is **indisputable**. Active commuting to school has been linked to lower fat mass among London primary schoolchildren, and daily sports activity is associated with stronger muscle development (Bosch et al. 2019). This evidence supports policy interventions that consist of a combination of actions to stimulate walking or cycling to school and daily extracurricular sports engagement. In order to be able to devise potentially successful interventions, a thorough understanding of the drivers of, and barriers to, children's physical activity in the home and school neighbourhood is crucial. Only by taking their interests, fears, concerns and wishes into account can the urban space be transformed into a place where children will happily walk, cycle, scooter, play and exercise. Nonetheless, it should be recognized that London is a very diverse city and a one-size-fits-all plan of action is unlikely to succeed, as the problems children are confronted with and possible ways to address these are likely to be highly context-specific.

Therefore, the present **policy paper** is the result of extensive fieldwork performed in the 2018/2019 academic year, assessing the built environment of primary schoolchildren in Brent. It **aims to establish which neighbourhood characteristics determine** their **commuting and sports decisions in the outdoor, public realm**. Following this introduction, the combination of go-along interviews, accelerometry and activity diaries employed to gather research evidence is outlined. Next, the findings for the Brent built environmental barriers to, and potential drivers of, children's outdoor activity are discussed, as well as participants' objective activity patterns collected through the accelerometers and diaries. Before concluding, the combination of concrete short- and long-term recommended policies stemming from these findings is listed. Their implementation has the potential to raise children's activity levels, and make Brent a truly inclusive Borough indeed.

The narratives presented in this report, constructed by Brent children themselves, should be heard and actively included in urban policymaking. Action is not only urgently required, it is also expected by the local community. As the mother of a participating child put it:

> *" I raise my concerns with you as you [are] trying to progress with doing something about it. Therefore **I hope** you are successful with what you are doing and **there is a change** [to the neighbourhood]. "*
>
> **– Mother of interviewed boy aged 8**

RESEARCH OUTLINE AND METHODOLOGY

The importance of **children's active inclusion in urban policy and planning** and the need to pay attention to the **context-specific dynamics** that underlie their physical activity choices guided the selection of a relatively novel research method used in this study: the **go-along interview**. This hybrid method combines traditional interviewing with the direct observation of participants' real-life, local environments, as the researcher-interviewer joins the interviewee while moving through the outdoor public space together (Carpiano 2009). In London, go-along interviews were employed to gain insight into children's built environments, and the challenges and opportunities for physical activity they encounter while crossing their home and school neighbourhoods every day. To comprehend and gain insight into these challenges and opportunities, the interviewer joined participating children on the way to or from school, or asked them to provide a guided tour through their home neighbourhoods. Along the way, participants then pointed out local drivers of, or barriers to, active commuting to school or exercise in the outdoor public space. Not only were the **children** thus given the role of **neighbourhood expert and guide**, they were also at liberty to develop their own, independent narratives as they could point out striking elements of their built environments freely. Besides the researcher, a second adult, related to the child and often a parent, accompanied the commute or neighbourhood tour for ethics purposes. However, it was made clear that the interview would primarily focus on the thoughts and ideas of participating children.

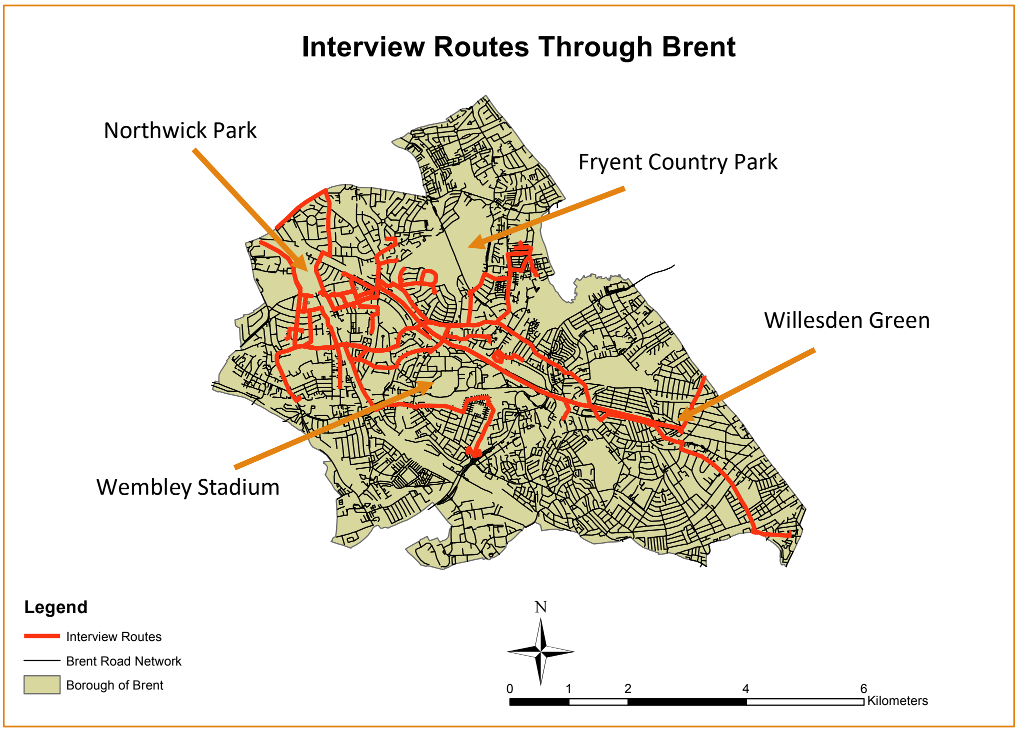


Figure 2: Interview routes through Brent for primary schoolchildren included in our study (Cartography by Author, 2019).

The present report is based on **57 go-along interviews** with a socioeconomically, geographically and ethnically diverse sample of eight-to-eleven-year-old primary schoolchildren attending three schools in the two selected Boroughs, Brent and Newham. Of these, 35 interviews were carried out in Brent. They took place between October 2018 and March 2019 - the darkest, wettest and coldest months of the year. Performing interviews in the six months with the worst climatic conditions allows the baseline activity and environmental experience of pupils to be established.

LONDON BOROUGH of BRENT

35	59.3 miles or 95.5 km	19 hours 27 minutes
Go-along interviews	Roads travelled	Interview data

The results is **59.3 miles,** or 95.5 kilometres, **travelled** across Brent (Figure 2), and a total of nearly twenty hours of interview data. Thirteen go-along interviews were carried out while walking to or from school, thirteen trips were passive school commutes either by car or public transport, while the final nine go-alongs were guided neighbourhood tours.

These interviews were **complemented by objective activity data** collected through accelerometers, devices similar to Fitbits that measure the duration, time and intensity of physical activity (Figure 3). Children were asked to wear these accelerometers for one school week following the go-along interview. This enabled us to match children's narratives to objectively measured activity levels, to study patterns of activity on weekdays and weekend days, and to see whether there is a link between the built environmental drivers or barriers children experienced and their actual activity.

Figure 3: Axivity AX3 **accelerometer** (Axivity.com)

The final aspect of the methodology consisted of activity diaries, short surveys accompanying the accelerometers for the duration of one week after the interview (Figure 4). Every evening before going to bed, the participant was asked to complete a couple of questions about their activity that day, focusing on the mode of commuting to school and engagement in sports, exercise and screen-based activities. By asking which activities the child engaged in and for how long, sense can be made of the accelerometer data, pointing out which activities occupied London's pupils and how frequently they took part in them.

This combination of qualitative go-along interviews and objective physical activity measurements paints a full picture of the daily activity routines of primary schoolchildren in Brent. Moreover, the direct exposure to those children's built environment experienced by the researcher – some of it supporting and inciting activity, some of it deterring them from being active – leads to a deeper comprehension of the extent to which Brent is a child-friendly Borough that includes and accounts for their presence. Based on the **real-life evidence** that emerges from this study, **policy recommendations** can be formulated, highlighting the strengths of Brent neighbourhoods, and suggesting areas where improvements need to be made or urgent intervention is required.

Figure 4: Activity diary examples for a weekday and weekend day (Author, 2018)

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TUESDAY

1) How did you travel to school today? Please tick:

Walking	Cycling	Car	Bus	Tube	Other:__________

How long did that take you? Please tick:

Less than 10 minutes	10 to 30 minutes	More than 30 minutes

2) How did you travel home again after school today? Please tick:

Walking	Cycling	Car	Bus	Tube	Other:__________

How long did that take you? Please tick:

Less than 10 minutes	10 to 30 minutes	More than 30 minutes

3) Did you do any of the following things today? When? Please tick, and write down how long you did them for in the last column:

Which Activity?	Before School	During School	After School	How long? (minutes/hours)
Running/Jogging				
Cycling/Scootering				
Football				
Dancing				
Tennis/Badminton				
Swimming				
Basketball				
Playing outside				
Trampolining				
(Dog) Walking				
Watching TV				
Gaming				
Surfing the internet				
Other sport/activity: PE (circuit)				

Did you do any other activity today you'd like to tell me about?:

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SATURDAY

Did you do any of the following things today? When? Please tick, and write down how long you did them for in the last column:

Which Activity?	Before Noon	Noon to 5pm	Evening	How long? (minutes/hours)
Running/Jogging				
Cycling/Scootering				
Football				
Dancing				
Tennis/Badminton				
Swimming				
Basketball				
Playing outside				
Trampolining				
(Dog) Walking				
Watching TV				
Gaming				
Surfing the internet				
Other sport/activity: __________				

Did you do any other activity today you'd like to tell me about?:

RESEARCH FINDINGS

Five key built environmental characteristics were found to significantly **hamper** the active commuting to school and the outdoor, extracurricular sports engagement of the interviewed primary schoolchildren in Brent. These are: the maintenance of pavements; traffic safety and air pollution around schools; greenspace maintenance; excessive centralization of services and activities, and remnants of criminal activity. Through their effect on activity, not addressing these barriers could also have detrimental impacts on children's health and wellbeing. **Four factors were potential key positive elements** that, if managed well, could contribute to stimulating children's out-of-school physical activity in the Borough: the availability of large recreation areas; the provision of weather-independent play and sports facilities; dead-end streets and home zones, and social cohesion.

This section explores these place-based and contextual barriers to and drivers of children's activity in-depth, with the aim of establishing concrete policy recommendations in the next section.

BUILT ENVIRONMENTAL BARRIERS TO PHYSICAL ACTIVITY

PAVEMENT MAINTENANCE

*“The path is really uneven, so if you want to scooter, or drive a bike, **you normally fall down**. Normally, the cars, they go on the pavement, and that makes the path uneven.”* **– Interviewed girl aged 9**

Nearly all participating children spontaneously expressed their strong **concern about the poor state of the pavements** in their home and school neighbourhoods. Indeed, large cracks in tiles, pits between paving stones and uneven humps frequently cause them to trip and hurt themselves, causing abrasions or painful bruises. These trip hazards also prohibit children from scooting, cycling or skateboarding to school, as wheels get stuck and cause children to fall over, or force them onto the road where high volumes of traffic pose a significant accident risk. In sum, this results in children feeling insecure when walking, cycling or scootering to school, and deters them from making the choice for an active mode of commuting. Moreover, while greenspace along the route is crucial, and children very much enjoy passing by plants and trees, these **should** also **be well-maintained**. Tree roots are potential trip hazards and low-hanging branches or high bushes cause reduced visibility, and, hence, road safety.

Pavements constitute an important part of children’s daily built environment. Children prefer to use pavements for all forms of active transport, as it allows them to avoid the road. Commuting pupils often interact closely with and care deeply for their surroundings along the way (Kullman 2014). Ensuring their commuting route is in an optimal state and safe is therefore key to inciting and enabling them to choose active modes of travelling to school and other destinations.

Photos: Poor pavement maintenance deters active commuting to school, by Author, 2019

TRAFFIC SAFETY & AIR POLLUTION AROUND SCHOOL

Around the start and end times of school, cars clogged the streets around the school entrance. Parents drop off children – engine running, brake lights flashing – taking up the entire road and parking on the pavement or carelessly swinging open doors, before rushing off home or to work. Despite the best efforts of schools to stimulate ‘Park & Stride’ policies or active commuting, this does not result in a sufficiently large number of parents leaving the car aside and walking, cycling or taking public transport to school. There is plenty of parking space provided in Brent, usually within a 10-minute walk from school, and bus and tube connections service the Borough well. Nonetheless, while children generally expressed a preference for active transport, especially in good weather conditions, parents frequently indicated a **preference for car transport** out of convenience or time-saving considerations. In combination with the poor maintenance of pavements and the absence of decent cycling infrastructure, this heavy reliance on cars poses a **significant safety risk** to the children who reach school on foot or by bike. Furthermore, the limited presence of **zebra crossings** controlled by traffic lights on major arteries such as The Avenue or Willesden Lane, connecting large residential areas, amplifies unsafe conditions.

> *“People decide not to park here [in the park] and walk, but instead they decide to drive all the way inside [the school street], and* ***stop outside the school*** *with their engine on. So I feel that, whilst it’s emanating the fumes, it’s* ***bad for the children****, because they’re also breathing in, and there’s a lot of them entering the school, to one place.”*
>
> **– Interviewed boy aged 10**

Photos: Unsafe traffic situations around school start times, by Author, 2019

Parents of pupils living far away from school in areas poorly served by public transport understandably opt for private transport for the daily commute of their children. However, as it takes a primary school child only just over fifteen minutes to walk a mile (1.6 kilometres), the choice to walk, cycle, scooter or skateboard for children living closer to school should be strongly encouraged (D’Haese at al. 2011, Toor et al. 2001). This will **bring down the volume of cars** on the road, increase road safety, and set an example inciting others to follow suit.

Moreover, reducing the number of cars around schools will lower **air pollution** levels in close proximity to the school gate, often experienced as extremely intrusive by the interviewed children. This has the potential to limit the detrimental health effects of exposure to toxic fumes from cars (Mudway et al. 2019). Participants referred to classes in school where they were taught about the effects of air pollution on child health, and expressed their disappointment at the lack of action in this regard. Lowering levels of harmful vehicle exhaust should therefore be a top priority for the Borough and schools.

GREENSPACE MAINTENANCE

The Brent schoolchildren participating in the study pointed out numerous elements of **greenspace** they found aesthetically **pleasing** or fun to play in. They experienced green open space and smaller patches of vegetation as a welcome and necessary balance to the primarily residential land use in the area. However, a common complaint concerned the **poor maintenance** of those elements in places such as Preston Park, Sherrans Farm Open Space, along the River Brent in Tokyngton or Chalkhill Park. High, unkept grass, fly-tipping, litter and, in particular, dog fouling were a nuisance to children and made them less keen to play outside. This went hand in hand with the presence of animals many children often find scary in these public spaces. Dogs that are being walked unleashed and foxes or rats roaming the streets looking for food repeatedly appeared to cause significant anxiety among the children.

Photos: Children enjoy open greenspace, however, they are deterred by poor maintenance, by Author, 2019

The presence of varied, lush and well-maintained greenspace in the children's built environments has been linked to their stronger cognitive development, improved mental and physical **health** and a closer connection with nature (Freeman et al. 2018; Vanaken and Danckaerts 2018). The narratives of the Brent schoolchildren provide ample support for these observations, thereby underlining the need to create and maintain greenspace throughout the Borough.

CENTRALIZATION OF SERVICES AND ACTIVITIES

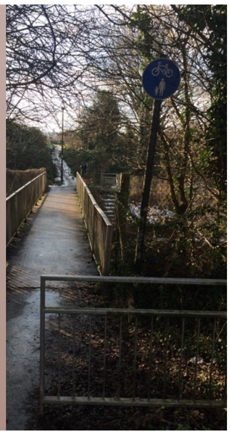
When crossing the neighbourhood, interviewed children who did not reside in central Brent often referenced that there was ***"little to do"*** around their house and school. Indeed, with the exception of several playgrounds, few public services or activities are available to Brent schoolchildren living in more suburban parts of the Borough such as Preston or Tokyngton. Services and activity opportunities have been centralized around the upmarket, regenerated and gentrified developments of Wembley Park. In contrast, the remaining services elsewhere increasingly come under threat of relocation or shutting down.

This is illustrated by the closure of **libraries** or their conversion to publicly-run community libraries. Aside from fostering reading, these smaller libraries provide a wide range of services, such as booster classes, chess clubs and film nights, all essential to the local community. Taking these away damages the social tissue in the neighbourhood, and makes children even less likely to have a walk to the library to get some books, attend a class or meet friends. The care for these places is thus pivotal to maintain thriving communities where children form a part of daily public life. Now, many children have to commute to the large Brent Library downtown, where traffic and vast numbers of people can be intimidating, and parents often do not find or make time to accompany their children. The risks and detrimental impact of such gentrification and relocation or change of services, out of sync with local needs, has been described recently for Hackney (Brown 2016), another London Borough where these processes are at play and have a significant negative impact on local communities.

Photos: Excessive centralisation of services damages the social tissue, by Author, 2019

REMNANTS OF CRIMINAL ACTIVITY

> *One year ago, **my brother and my neighbour** went to the park, and on the way back, they **got robbed by** these two **teenagers**. [...] They had a big knife with them. They threatened...*
>
> **– Interviewed boy aged 10**



Several children described detailed personal **experiences with crime** in the Borough, particularly those residing in Neasden and Preston. These children elaborated on how the fear of crime restrained their outdoor activity, as they felt more safe indoors. This instilled a justified sense of anxiety among those interviewees. In academic literature, ample reference is made to 'stranger danger', described as a moral panic among parents and children resulting from fears concerning the personal safety of the child in the public space.

However, the figures on knife **crime** and children's experiences demonstrate that these **concerns** are **not** always **irrational** or overstated, but the result of a difficult reality. Brent had the fourth-highest volume of knife crime offences of any London Borough over the financial year 2017/18 (MOPAC 2018). London and Brent authorities strive to reduce the risk and number of knife crime and related incidents (Mayor of London 2017; Safer Brent 2018). Nonetheless, as long as incident rates remain high, children in Brent are still exposed to the threat posed by knife and other crime. Whilst these offences tend to be confined to a small number of hotspots in Brent (Safer Brent 2018), children and parents frequently brought up personal safety as a prime concern during the interview, irrespective of whether they lived in close proximity to such hotspots or not. This fear of children's personal safety was amplified by the frequent burglaries and thefts in interviewees' home neighbourhood, highlighted by the many 'Criminals Beware' signs across the Borough.

Unaccompanied, free play is especially likely to suffer under the consequences of this anxiety among adults and children, as parents felt uncomfortable allowing their children to play outside without supervision, mentioning that this might be perceived as 'bad parenting'. This supports earlier evidence that UK parents fear being judged by other members of the public if they allow their children to play and be outside unsupervised (Community Practitioner 2013), resulting in a culture of parenting that counteracts an active lifestyle. Knife and other crime thereby not only causes anxiety among Brent residents, it also has a profound health impact through a reduction in children's physical activity levels.

Photos: A crime scene and signage warning criminals in Brent, by Author, 2019

BUILT ENVIRONMENTAL STIMULI OF PHYSICAL ACTIVITY

LARGE RECREATION AREAS

While the predominant land use in large parts of Brent is residential, several extensive open **recreation** areas are available for children to enjoy, particularly in the northern part of the Borough. Importantly, these tend to be located **in close proximity to schools**, allowing children and their parents to spend some time in the park or recreation ground after school, as opposed to heading straight home. This after-school use of play and sports facilities close to school has been observed in earlier studies (Veitch et al. 2007).

Stimulating this 'easy' physical activity is key to enhancing children's extracurricular activity levels. To that end, it is necessary to ensure these areas can be safely and quickly accessed, and offer a diverse range of activity opportunities will boost their use even further. The research participants expressed a clear preference for monkey bars, climbing frames, slides and swings, and – perhaps surprisingly – also the outdoor gyms implemented across the Borough. Despite their initial purpose of stimulating adult exercise, children see those tools as an exciting challenge, and often attempt to imitate their parents or other adults using the equipment. Evidence on children's use of these facilities is scarce (Cranney et al. 2016), though these findings highlight their importance for both adults and children.

Photos: Northwick Park and the gym in Preston Park, particularly popular after school, by Author, 2019

WEATHER-INDEPENDENT PLAY FACILITIES

Despite the presence of these outdoor recreation opportunities, children said they were significantly less active during winter months, a 'hibernation' widely reported in prior literature (Tucker & Gilliland 2007). Hence, while children should be encouraged to participate in outdoor play and exercise throughout the year, the provision of facilities that boost **physical activity independent of the climatic conditions** is crucial. In Brent, several facilities were highlighted as particularly good examples of activity stimuli irrespective of the weather. The swimming pool in Brent Leisure Centre ('Better') proved particularly popular, not only as a place to have fun and be active, but also as a social actor, constituting a place to meet friends and family. Moreover, as swimming does not require extensive training or expensive equipment and is usually supervised, it has a low engagement threshold. Expanding the number and capacity of swimming pools in the Borough and ensuring they are easily accessible to all children – both in terms of transport and finance – is key to maximize their potential. This will enable more children to be active throughout the year, and not only in the summer months when the weather conditions are optimal.

Aside from fully indoor activity opportunities, the **covered, semi-outdoor play facility** at the London Designer Outlet attracted many children and parents. For parents, the combination of having a coffee or doing some shopping whilst being able to combine this with their children's supervised play was a very appealing opportunity that was frequently taken up. For the interviewed children, the dry and well-maintained play equipment and limited exposure to the elements was attractive. While outdoor playgrounds need thus to be provided across the Borough and are particularly important in summer, the wider implementation of covered facilities could be a pathway to stimulate children's activity in the coldest and wettest months of the year while reducing parents' barriers to supporting their children's activity.

Photos: The London Designer Outlet: a successful combination of play and shopping, by Author, 2019

DEAD-END STREETS AND HOME ZONES

Across the Borough, high volumes of traffic in the streets around children's homes were cited by children and their parents as detrimental to outdoor play. Busy roads pose a significant health and safety risk indeed, and make children feel unwelcome in the public realm. However, research participants living in **cul-de-sacs**, which tend have **higher levels of road safety**, formed an exception to this wider pattern. The role of dead-end streets as potential stimuli of children's play and activity has been previously noted in the UK and abroad (Brockman et al. 2011). Also for the Brent sample, driveways, pavements and even the roads in cul-de-sacs themselves were perceived as an integral part of the public play space to be used and enjoyed by children for their commuting and play. Parents highlighted that local residents also paid more attention to playing children in those streets, as there was a certain expectation children could be active outside.

Photos: Cul-de-sacs and home zones incited Brent schoolchildren's outdoor play, by Author, 2019

Moreover, just over a decade ago, **Brent** was cited as a **successful example** of London's **Home Zone Project** (Gill 2007). Such areas, where the living environment takes precedent over traffic provisions and child pedestrians have priority over motorized vehicles, are key in creating a safe environment for children to engage in free, outdoor activity, which was also noted during the interviews. Hence, capitalizing on this success and reigniting the Borough's commitment to creating a road environment that is welcoming to children and their outdoor activity might strongly contribute to raising their active transport and play in the public space.

SOCIAL COHESION

When moving through the neighbourhood, either on the way to or from school or during a guided tour, children pointed out places where friends and family lived, and spoke cheerfully about how they enjoyed greeting or **chatting to other kids** or acquaintances **along the way**. The importance of social cohesion in local communities in stimulating physical activity and independent mobility among children has been detailed in previous studies (Schoeppe et al. 2015), and appears crucial for children's enjoyment of outdoor activity in Brent as well.

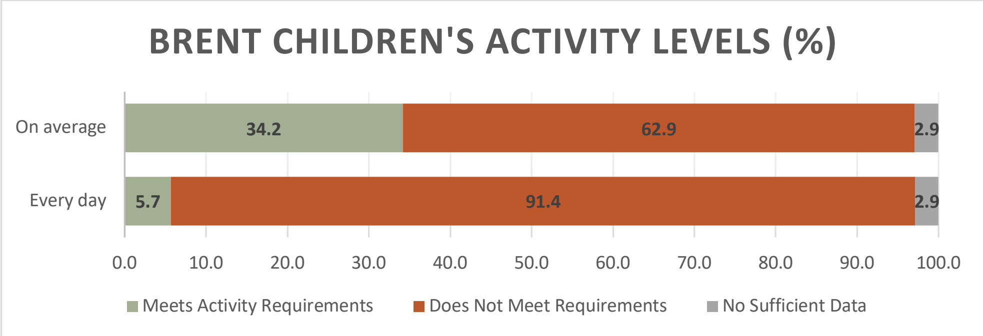
However, the large volume of children travelling to school by private transport and the reduction of services and free outdoor play in the neighbourhood puts these spontaneous interactions at risk. Hence, ways to **promote social cohesion** in Brent are required, to ensure children can experience the fun and benefits of impromptu social exchanges during their daily commute or time spent in the outdoors out of school. Moreover, increased social cohesion also has been shown to appease adults' concerns about the neighbourhood and is thus a potential driver of children's independent mobility in the public space (Schoeppe et al. 2015).

Photos: Children enjoy social interaction along the way to school, by Author, 2019

ACCELEROMETER AND ACTIVITY DIARY DATA

The interviewed children's narratives provide a gripping insight into both the positive and negative aspects of the daily neighbourhood experience of Brent primary schoolchildren. These narratives were complemented by information gathered through accelerometry and activity diaries, to obtain an insight into the objective activity patterns of those pupils. As Figure 5 shows, only 5.7% of Brent children included in our sample met the minimum requirement of 60 minutes of moderate-to-vigorous activity every day (WHO 2019). On average, however, the image is slightly more positive, with 34.2% of children accumulating 420 minutes of moderate-to-vigorous activity in one week. This is equivalent to the one-hour daily target. Nonetheless, at 62.9%, the **proportion of children not meeting the activity requirements** is still **nearly twice as large**.

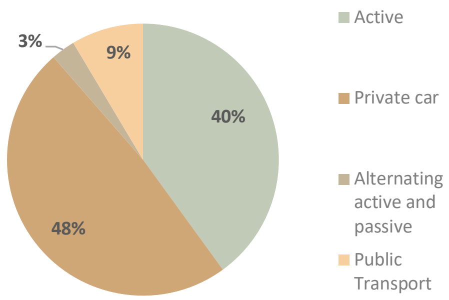
Figure 5: Activity levels for interviewed children in Brent, percentage meeting 60 minutes of moderate-to-vigorous activity based on strict WHO criteria and on average



As Figure 6 shows, only 40% of interviewed children predominantly walked, cycled or scootered to and from school during the week following their interview, whereas about half mainly used the car. About thirty percent of those passive commuters lived within the walkable distance of one mile. The need to address built environmental barriers to achieve an increase in children's physical activity is thus clear and urgent. **Stimulating active commuting** is one particularly promising pathway in that respect, especially through its links with lower obesity levels (Bosch et al. 2019).

These low levels of physical activity become even more striking as it can be noted that children collected **most** of their **activity on weekdays,** and particularly **during school hours**. On a school day, over half of children's activity (55.9%) took place between the start and end of school. The school thus seems to play a crucial role, not only in providing education, but also in stimulating children's activity. Children were less active on the weekend. The Brent schoolchildren in our study collected an average of 54.7 minutes of moderate-to-vigorous activity on a regular school day, versus only 38.5 minutes on an average Saturday or Sunday. This implies that, with the right neighbourhood incentives, **significantly more extracurricular activity can be gained**. This will allow more children to meet minimum activity requirements.

Figure 6: Dominant mode of commuting for interviewed children in Brent



"Sometimes I ask: "But ***why do we have to take the car****", because we don't live that far..."*

– Girl aged 9 being driven to school living less than a mile away

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POLICY RECOMMENDATIONS FOR BRENT COUNCIL & SCHOOLS

The interviews resulted in the collection of a diverse set of inspiring and grounded accounts of children's everyday life in the Brent built environment. Children view their surroundings differently from adults, often interacting more closely with it, and experiencing barriers and stimuli grown-ups don't notice (Gascon et al. 2016). Throughout the research, participating pupils proved capable of building a coherent argument, elaborating carefully on the benefits or downsides of environmental aspects, and often suggesting creative yet realistic solutions to address challenges and bolster strengths. Therefore, to make future urban design and policy development truly inclusive, the **installation of a Brent children's panel** is strongly encouraged. This guarantees their voice is directly accounted for in the Boroughs' policymaking, and actively recognizes them as key constituents of local communities.

For Brent Borough Council and schools, the built environmental barriers and stimuli described by the interviewed children provide a strong impetus for the implementation of policies that stimulate their choice for active commuting to school and engagement in outdoor, extracurricular sports. Managing child activity and weight status is not the sole responsibility of parents. Through its built environment, the Borough plays a crucial role in inciting physical activity and reducing the obesity epidemic. Therefore, **for each of the built environmental obstacles and drivers, two policy recommendations** were designed that could significantly contribute to inciting higher activity levels among primary schoolchildren in the Borough. This results in a 18-point policy plan for the Borough Council and schools to address the flaws and harness the strengths of Brent's built environment.

TACKLING BUILT ENVIRONMENTAL BARRIERS TO PHYSICAL ACTIVITY

PAVEMENT MAINTENANCE (RECOMMENDATIONS 1 & 2)

- Immediately embark upon the urgently-needed **repair** of the cracks and pits in **pavements** in Brent. These are currently significant trip hazards that discourage children from actively commuting. The streets directly around schools should be prioritized, and the update of pavements should subsequently be rolled out over time across the Borough. Moreover, bike lanes should be implemented, separated from traffic and pedestrians, to enable safe cycling to school. Schools can consider facilitating children's use of bicycles even further by inviting bicycle doctors to fix technological problems children experience with their bikes.

- Create a **'Pavement Alert'** for Brent, where children and their parents can report particular places where pavements are problematic, visibility is limited, or crossings are inadequate, affecting children's safety in the public space. Inspiration and experience can be drawn from a similar, highly successful initiative in Oslo, called 'Traffic Agents' (https://www.trafikkagenten.no).

TRAFFIC SAFETY & AIR POLLUTION AROUND SCHOOL (RECOMMENDATIONS 3 & 4)

- Permanent **prohibitions for non-residents and one-way systems** in narrow school streets should be considered. Should permanent action not be possible, then temporary closures or one-way traffic systems from 15 minutes before to 15 minutes after school start and end times are the bare minimum to allow for children's safe access to school. Aside from encouraging active commuting, these measures will reduce the disruption experienced by local residents, and schools and residents should report infringements. In return, park-and-stride opportunities should be provided for adults picking up and dropping off children within a 10-minute walk from school. Parking should be free in the hour around school start and end times in those designated parking areas.

- Brent Council and schools should **enforce measures against antisocial behaviour** of adults dropping off or picking up children at school. This can be done through awareness campaigns at schools, but local police services should also consider holding (un)announced patrols, controlling for cars parking on pavements or holding up traffic by dropping off children whilst stationary on the road.

GREENSPACE MAINTENANCE (RECOMMENDATIONS 5 & 6)

- Ensure sufficient **staff** are employed **to maintain greenspace** in the Borough. Keep grassy areas short, except in specific areas designated to stimulate vital biodiversity, remove litter, and restrict where dogs can be walked without leash. Children are often scared of dogs chasing them or coming too close. Hence, the areas where dogs are allowed to roam freely should be well-defined, and children's needs should take precedence over dogs' at all times.

- **Actively patrol** for dog waste, litter and fly-tipping, and fine perpetrators. Ensuring neighbourhood and greenspace cleanliness is a joint responsibility. Hence, reports of antisocial behaviour should be encouraged and quickly acted upon. Moreover, schools could organize 'cleaning-up brigades', whereby children jointly clean up the area around school, in combination with classes on the environmental impact of waste.

CENTRALIZATION OF SERVICES AND ACTIVITIES (RECOMMENDATIONS 7 & 8)

- **Maintain the presence of local services** such as libraries and modern play spaces across the Borough and not solely in the gentrified area around Wembley Park. A diverse and attractive neighbourhood will inspire active commuting, social cohesion and children's personal development and health.

- **Ensure** central services can be easily accessed by **public transport**. Access should be interpreted both physically, by operating frequent and geographically evenly spread transport services, and financially, by limiting fees and keeping local transport affordable for all.

REMNANTS OF CRIMINAL ACTIVITY (RECOMMENDATIONS 9 & 10)

- Criminal activity in Brent can and should not be ignored, and remnants of criminal activity should immediately be removed. Once a clean and safe neighbourhood is guaranteed, schools and Borough should then raise awareness that encouraging **free, outdoor play** is not a sign of bad parenting – quite the opposite: it should be considered a **must** for child health and cognitive, physical and social development. To that end, supervised play and recreation opportunities should be provided in the public space, fostering social cohesion and physical activity.

- Assist the efforts to **fight the knife crime epidemic** where possible, in particular in relation to youth crime. This should not only be done through police action: schools can also play a role by providing a trusted and confidential contact person who provides information to pupils and allows them to share experiences and fears encountered in the neighbourhood. This can highlight areas of concern that need urgent addressing.

HARNESSING BUILT ENVIRONMENTAL STIMULI OF PHYSICAL ACTIVITY

LARGE RECREATION AREAS (RECOMMENDATIONS 11 & 12)

- Stimulate the **post-school use of large recreation areas** by maintaining these well and providing a diverse range of play and exercise opportunities for both children and adults. Schools can organise regular sports days or after-school activities here to stimulate their use by pupils, as can Boroughs in the evenings, on weekends and during holidays.

- Make these recreation facilities **easily accessible** by ensuring safe crossings and road obstacles slowing down traffic. This will incite children’s joint play, and might inspire them to commute actively to school.

WEATHER-INDEPENDENT PLAY FACILITIES (RECOMMENDATIONS 13 & 14)

- Increase the number and capacity of **indoor recreation facilities**, and swimming pools in particular, whilst making these financially and physically accessible to all children in the Borough. These should not solely be located in Wembley Park, but evenly spread across the Borough to allow all children to participate in sports and exercise.

- **Replicate the success of the covered play facility** around the London Designer Outlet by providing similar activity opportunities close to places frequently visited by parents, such as shops and food outlets throughout Brent, again not focusing solely on the Borough's economic and gentrified heartland.

DEAD-END STREETS AND HOME ZONES (RECOMMENDATIONS 15 & 16)

- Introduce **traffic barriers to create** more **cul-de-sacs** where possible, and reduce the volume and speed of traffic in secondary roads to allow children to use roads for active commuting and outdoor play.

- Seeing their successful implementation in recent decades, **expand** dramatically the **number and extent of home zones**, especially in the most residential parts of the Borough. Raise awareness about the aim of these zones to allow pedestrians, and particularly children, to use roads for physical activity and leisure purposes, in which they take precedence over motorized vehicles.

SOCIAL COHESION (RECOMMENDATIONS 17 & 18)

- Ensure children and adults know each other and get the opportunity to play together by providing **supervised neighbourhood** sports and play **sessions** in the outdoors.

- Schools are strongly encouraged to organize **walking school buses**. Moreover they should consider **rewarding** children living within a mile from school for **walking/cycling to school**, and those living further away for using public transport. This could be done for instance by handing out stickers or allowing them first pick for certain in-school activities.

Photos: Northwick Park on a snowy morning in February, by Author, 2019

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CONCLUSION

Seeing children walk or cycle to school and play outside used to be a common sight until a couple of decades ago. However, while the share of children growing up in cities keeps rising, their presence in the urban environment has significantly declined. Changes to the built environment in children's home and school neighbourhoods play an important role in this decline, which has seriously contributed to the double epidemic of children's inactivity and obesity.

Based on go-along interviews with a sample of primary schoolchildren, this report assessed the strengths and weaknesses of the neighbourhood built environment of children in Brent in stimulating their outdoor physical activity. The narratives that emerged when crossing the neighbourhood with participating children paint an intense and detailed picture of their daily physical activity.

Children living in Brent grow up in a Borough where **significant barriers to** their outdoor **physical activity** exist, which should be urgently addressed. Unsafe neighbourhoods with a high volume of traffic and poorly maintained pavements deter their active commuting to school. Poor maintenance of greenspace and a lack of local services and facilities then adds to a reduction of these children's outdoor play and active transport.

However, whilst these challenges require immediate action, Brent can also rely on **several unique built environmental stimuli** that could potentially incite children's active commuting to school and sports engagement. The availability of large recreation areas, home zones and weather-independent play facilities can, if managed well, add significantly to their physical activity outside of school throughout the year. Similarly, stimulating social cohesion will allow even more children to commute actively to school or play outside. Much progress is still to be made here, as shown by the accelerometry and activity diaries.

The **policy recommendations** for Brent Council and schools in the Borough – some more ambitious and involving many actors, other more focused and easily implementable in the short term – hold the potential to contribute significantly to the aim of **raising children's activity levels** and making the Borough, and London at large, a city where "everyone is welcome" indeed. Through the implementation of these suggested measures, physical structural prevention making the active and healthy choice the easier and default option is built into the Borough (Troelsen et al. 2013). Taking the health and wellbeing of future generations into account in urban design and planning is key, and it is hoped this report can contribute to shaping Brent into a healthy, diverse and inclusive Borough.

ACKNOWLEDGMENTS

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Appendix 6 – Newham Council Report

2019

The Newham Where We Grow Up

Investigating the Built Environment of Newham Primary Schoolchildren from a Daily Physical Activity Perspective

POLICY REPORT PREPARED FOR NEWHAM BOROUGH COUNCIL

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Cover Photo: Beckton District Park, by Author, 2018

THE NEWHAM WHERE WE GROW UP

INVESTIGATING THE BUILT ENVIRONMENT OF NEWHAM PRIMARY SCHOOLCHILDREN FROM A DAILY PHYSICAL ACTIVITY PERSPECTIVE

Policy report prepared for Newham Borough Council by Lander S.M.M. Bosch

ESRC & Gonville Scholar, Department of Geography, University of Cambridge

July 2019

Photo: Canning Town Station, by Author, 2018

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FOREWORD

'London. Everyone welcome.' For those millions using the London public transport network every single day, this slogan has become a part of their daily commute. London portrays itself as an open city, a global city, an inclusive city. Nonetheless, there are clear signs that indicate not every group might be equally well-represented or made feel at home in the UK's capital.

This report is the product of an investigation into the daily life in London of one of those groups: **primary schoolchildren**. London's youngest citizens – future adults, parents, policymakers and voters – rarely feature in policy documents, and reference to their inclusion and wellbeing often serves a purely tokenistic purpose. Hence, the need to engage with and profoundly understand the reality of London children's outdoor livelihoods is fundamental. At these testing times for London and the UK at large, there is significant urgency to address the challenges presented by the physical environment to which young Londoners are directly exposed every single day. Acting on these challenges and striving to make the built environment inclusive for children might, by consequence, contribute significantly to helping London become truly welcoming for everyone.

This report takes up this challenge by **exploring the built environment** of primary schoolchildren **in the Borough of Newham**, East London. Importantly, it does so by actively **including children's own voices** as knowledgeable experts of their own neighbourhood's strengths and flaws. Part of a larger, London-wide doctoral study currently being carried out at the University of Cambridge, it attempts to shed light on the relation between characteristics of children's outdoor surroundings and the way in which these form barriers to or stimulate physical activity in the public space. This report, together with the policy report produced for the London Borough of Brent, precedes the publication of the author's full doctoral thesis on the relation between the built environment, physical activity and body composition for primary schoolchildren across London, expected in the first half of 2021.

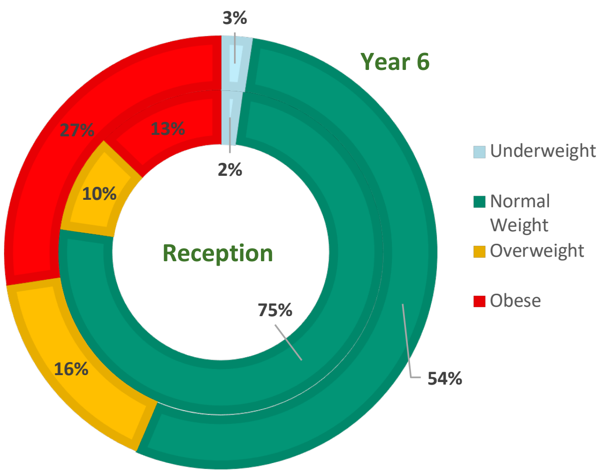
Lander Bosch, July 2019

Image: David Shrigley for TfL & Mayor of London, 2016

INTRODUCTION

London is confronted with a **double crisis** affecting its youngest citizens. On the one hand, children are **less active** than ever before. Under a quarter of London schoolchildren meet the minimum physical activity recommendations of 60 daily activity minutes of moderate-to-vigorous intensity, while over 40% do not gather more than 30 minutes every day (Townsend et al. 2015). On the other, levels of **childhood overweight and obesity** continue to rise. On average, over one out of five children of reception age across London are currently confronted with overweight or obesity. By Year 6, this has risen to nearly four out of ten being overweight or obese (London Datastore 2019). In Newham, home to over 37,000 children of primary school age (ONS 2018), this situation is particularly concerning. With 23% of children with overweight and obesity at reception age and 43% in Year 6, the Borough ranks third of all London Boroughs in terms of childhood overweight and obesity (Figure 1).

Figure 1: Childhood Overweight and Obesity Levels in Newham for Primary Schoolchildren of Reception Age and in Year 6 (Data: London Datastore 2019).



Given this double epidemic of childhood inactivity and overweight and obesity, the **need for urgent action** to reverse this situation is **indisputable**. Active commuting to school has been linked to lower fat mass among London primary schoolchildren, and daily sports activity is associated with stronger muscle development (Bosch et al. 2019). This evidence supports policy interventions that consist of a combination of actions to stimulate walking or cycling to school and daily extracurricular sports engagement. In order to be able to devise potentially successful interventions, a thorough understanding of the drivers of, and barriers to, children's physical activity in the home and school neighbourhood is crucial. Only by taking their interests, fears, concerns and wishes into account can the urban space be transformed into a place where children will happily walk, cycle, scooter, play and exercise. Nonetheless, it should be recognized that London is a very diverse city and a one-size-fits-all plan of action is unlikely to succeed, as the problems children are confronted with and possible ways to address these are likely to be highly place- and context-specific.

Therefore, the present **policy paper** is the result of extensive fieldwork performed in the 2018/2019 academic year, assessing the built environment of primary schoolchildren in Newham. It **aims to establish which neighbourhood characteristics determine** their **commuting and sports decisions in the outdoor, public realm**. Following this introduction, the combination of go-along interviews, accelerometry and activity diaries employed to gather research evidence is outlined. Next, the findings for the Newham built environmental barriers to, and potential drivers of, children's outdoor activity are discussed, as well as participants' objective activity patterns collected through the accelerometers and diaries. Before concluding, the combination of concrete short- and long-term recommended policies stemming from these findings is listed. Their implementation has the potential to raise children's activity levels, and make Newham a truly inclusive Borough indeed.

The narratives presented in this report, constructed by Newham children themselves, should be heard and actively included in urban policymaking. Action is not only urgently required, it is also expected by the local community. As the mother of a participating child put it:

> *"A lot of children are obese, but the Council don't do anything about it, they just measure.* ***I hope and pray this research will lead to something for the kids.*** *Because looking at Beckton [part of Newham] here, they could do something for the kids as well instead of just measuring them..."*
>
> **– Mother of interviewed boy aged 10**

RESEARCH OUTLINE AND METHODOLOGY

The importance of **children's active inclusion in urban policy and planning** and the need to pay attention to the **context-specific dynamics** that underlie their physical activity choices guided the selection of a relatively novel research method used in this study: the **go-along interview**. This hybrid method combines traditional interviewing with the direct observation of participants' real-life, local environments, as the researcher-interviewer joins the interviewee while moving through the outdoor public space together (Carpiano 2009).

In London, go-along interviews were employed to gain insight into children's built environments, and the challenges and opportunities for physical activity they encounter while crossing their home and school neighbourhoods every day. To comprehend and gain insight into these challenges and opportunities, the interviewer joined participating children on the way to or from school, or asked them to provide a guided tour through their home neighbourhoods. Along the way, participants then pointed out local drivers of, or barriers to, active commuting to school or exercise in the outdoor public space. Not only were the **children** thus given the role of **neighbourhood expert and guide**, they were also at liberty to develop their own, independent narratives as they could point out striking elements of their built environments freely. Besides the researcher, a second adult, related to the child and often a parent, accompanied the commute or neighbourhood tour for ethics purposes. However, it was made clear that the interview would primarily focus on the thoughts and ideas of participating children.

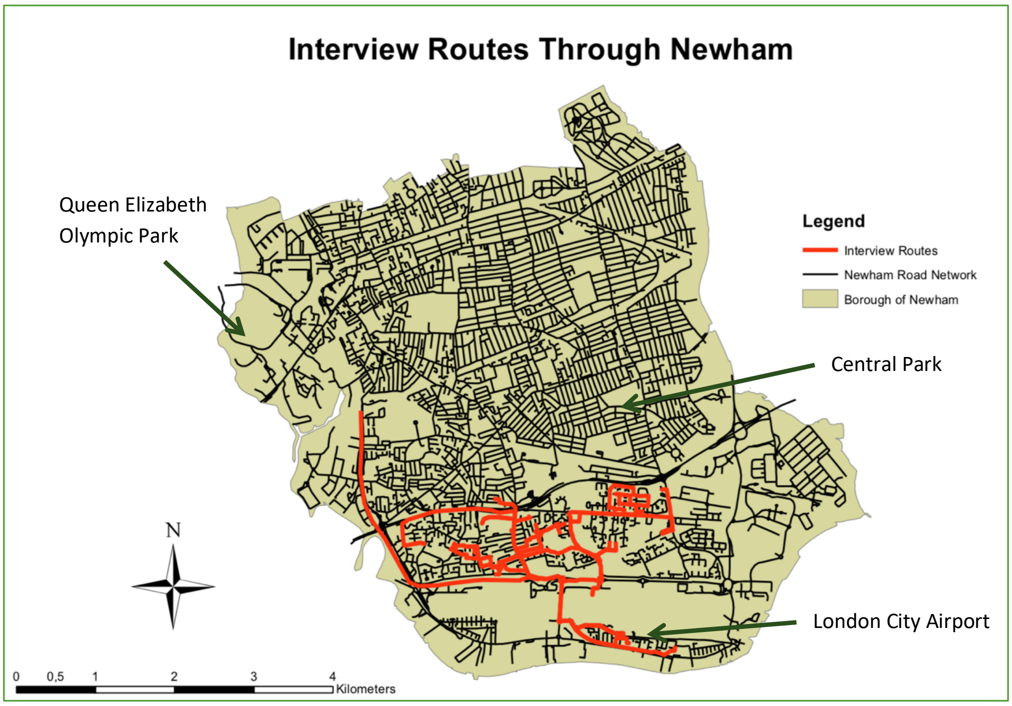


Figure 2: Interview routes through Newham for primary schoolchildren included in our study (Cartography by Author, 2019).

The present report is based on **57 go-along interviews** with a socioeconomically, geographically and ethnically diverse sample of eight-to-eleven-year-old primary schoolchildren attending three schools in the two selected Boroughs, Brent and Newham. Of these, 22 interviews were carried out in Newham. They took place between October 2018 and March 2019 - the darkest, wettest and coldest months of the year. Performing interviews in the six months with the worst climatic conditions allows the baseline activity and environmental experience of pupils to be established.

LONDON BOROUGH of NEWHAM

22	28.5 miles or 45.9 km	10 hours 49 minutes
Go-along interviews	Roads travelled	Interview data

The results is **28.5 miles,** or 45.9 kilometres, **travelled** across Newham (Figure 2), and a total of nearly eleven hours of interview data. Eleven go-along interviews were carried out while walking to or from school, six trips were passive school commutes either by car or public transport, while the final five go-alongs were guided neighbourhood tours.

These interviews were **complemented by objective activity data** collected through accelerometers, devices similar to Fitbits that measure the duration, time and intensity of physical activity (Figure 3). Children were asked to wear these accelerometers for one school week following the go-along interview. This enabled us to match children's narratives to objectively measured activity levels, to study patterns of activity on weekdays and weekend days, and to see whether there is a link between the built environmental drivers or barriers children experience and their actual activity.

Figure 3: Axivity AX3 **accelerometer** (Axivity.com)

The final aspect of the methodology consisted of activity diaries, short surveys accompanying the accelerometers for the duration of one week after the interview (Figure 4). Every evening before going to bed, the participant was asked to complete a couple of questions about their activity that day, focusing on the mode of commuting to school and engagement in sports, exercise and screen-based activities. By asking which activities the child engaged in and for how long, sense can be made of the accelerometer data, pointing out which activities occupied London's pupils and how frequently they took part in them.

This combination of qualitative go-along interviews and objective physical activity measurements paints a full picture of the daily activity routines of primary schoolchildren in Newham. Moreover, the direct exposure to those children's built environment experienced by the researcher – some of it supporting and inciting activity, some of it deterring them from being active – leads to a deeper comprehension of the extent to which Newham is a child-friendly Borough that includes and accounts for their presence. Based on the **real-life evidence** that emerges from this study, **policy recommendations** can be formulated, highlighting the strengths of Newham neighbourhoods, and suggesting areas where improvements need to be made or urgent intervention is required.

Figure 4: Activity diary examples for a weekday and weekend day (Author, 2018)

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TUESDAY

1) How did you travel to school today? Please tick:

Walking	Cycling	Car	Bus	Tube	Other:__________

How long did that take you? Please tick:

Less than 10 minutes	10 to 30 minutes	More than 30 minutes

2) How did you travel home again after school today? Please tick:

Walking	Cycling	Car	Bus	Tube	Other:__________

How long did that take you? Please tick:

Less than 10 minutes	10 to 30 minutes	More than 30 minutes

3) Did you do any of the following things today? When? Please tick, and write down how long you did them for in the last column:

Which Activity?	Before School	During School	After School	How long? (minutes/hours)
Running/Jogging				
Cycling/Scootering				
Football				
Dancing				
Tennis/Badminton				
Swimming				
Basketball				
Playing outside				
Trampolining				
(Dog) Walking				
Watching TV				
Gaming				
Surfing the internet				
Other sport/activity: PE (circuit)				

Did you do any other activity today you'd like to tell me about?:

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SATURDAY

Did you do any of the following things today? When? Please tick, and write down how long you did them for in the last column:

Which Activity?	Before Noon	Noon to 5pm	Evening	How long? (minutes/hours)
Running/Jogging				
Cycling/Scootering				
Football				
Dancing				
Tennis/Badminton				
Swimming				
Basketball				
Playing outside				
Trampolining				
(Dog) Walking				
Watching TV				
Gaming				
Surfing the internet				
Other sport/activity: __________				

Did you do any other activity today you'd like to tell me about?:

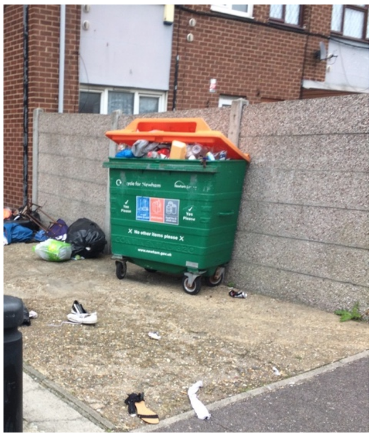
RESEARCH FINDINGS

Six key built environmental characteristics were found to significantly **hamper** the active commuting to school and the outdoor, extracurricular sports engagement of the interviewed primary schoolchildren in Newham. These are: neighbourhood cleanliness; seasonality; the lack of shared public spaces; remnants of criminal activity; the food environment around schools, and airplane noise. Through their effect on activity, not addressing these barriers could also have detrimental impacts on children's health and wellbeing. **Three factors were potential key positive elements** that, if managed well, could stimulate children's out-of-school physical activity in the Borough: physical challenges for children along their commuting routes; the provision of recreation facilities, and pedestrian-only alleyways.

This section explores these place-based and contextual barriers to and potential drivers of children's activity and health in-depth, with the aim of establishing concrete policy recommendations in the next section.

BUILT ENVIRONMENTAL BARRIERS TO PHYSICAL ACTIVITY

NEIGHBOURHOOD CLEANLINESS



Children's prime concern when crossing their home and school neighbourhoods in Newham was the **cleanliness of the built public space**. Indeed, overflowing bins, empty gas canisters, fly-tipping and other forms of waste are found across the Borough, and parents often need to resort to cleaning rubbish themselves. The most frequently reported source of waste was dog fouling, which sparked particular discomfort among the participating children. The problem was more common in parks and in the smaller alleyways that cut through the Borough, and less present or disturbing along main roads across Newham.

The consequences of inadequate neighbourhood maintenance go beyond simple aesthetics and smell. Waste in the built environment has been linked to health hazards for the general public, as well as crime (Hastings et al. 2009). Litter left unattended attracts potential pests, and faeces carry bacteria that pose public health risks. Adequate waste control and management are thus indispensable, and of particular importance in dense, inner-city areas like Newham (Hastings et al. 2009). Clean urban environments are then **likely to incite outdoor activity**, as they allow children and their parents to commute and play care-free.

Photos: Poor maintenance of clean public spaces in Newham, by Author, 2018

SEASONALITY

The go-along interviews were carried out between October and March, in the least pleasant climatic conditions and during the shortest days of the year. This afforded insight into the effects of seasonality on children's activity choices. The interviewed pupils in Newham experienced serious limitations to their engagement in outdoor exercise and active commuting to school due to the weather in autumn and winter, with darkness posing particular safety concerns. Children frequently experience phobias, and darkness-related anxiety is common (King et al. 2005). Children in Newham were particularly concerned about dark alleyways that formed part of their daily commute on dark mornings or afternoons in winter. They shared their preference for a longer route along better-lit roads, to reduce the risk that *"something might happen".* These fears are related to both traffic safety, as some main roads lack safe crossings, and personal safety, with abduction being the predominant worry.

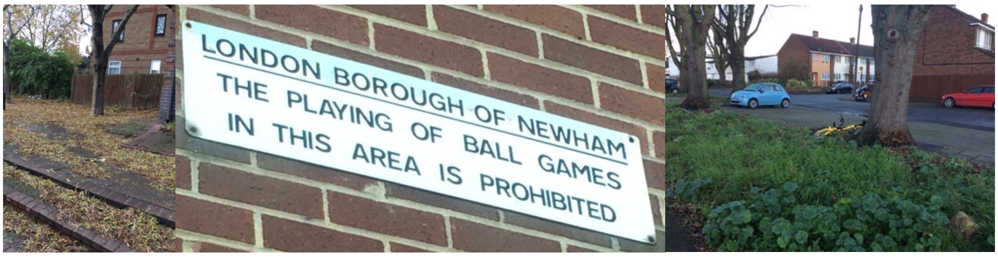
Photos: The consequences of seasonality and darkness in Newham, by Author, 2018

Moreover, poor weather conditions also deterred children from actively commuting or performing outdoor exercise. Poorly-lit crossings such as those on Freemasons Road, cold and wet play equipment and poor road maintenance create unsafe or unpleasant environments for physical activity. Children in the UK have been shown to have lower activity in autumn and winter (Atkin et al. 2016). This **'hibernation' of children** could also be noted for the Newham sample, as children drew attention to the fact that the climatic conditions during the coldest half of the year resulted in prolonged periods of sedentary time. Maintaining activity throughout the year is therefore key, as children are recommended to meet at least 60 minutes of moderate-to-vigorous physical activity on a daily basis.

SHARED PUBLIC SPACES

Interviewed children expressed a desire for an **increase in the number of shared public spaces**, where – aside from other public functions – free play and sports engagement are encouraged. Many open spaces in the Borough are currently car-dominated parking spaces or large areas covered in concrete or poorly maintained greenery. Children described feeling unwelcome in a wide variety of public areas, ranging from the road environment where the lack of safe, distinct cycling lanes deters them from considering cycling as a way of commuting, to the 'No Ball Game' signs that can be found throughout the Borough. This discourages many children from walking, cycling or playing, and leads to unpleasant encounters between the few children defying these challenges and members of the public who do not support their shared use of public spaces.

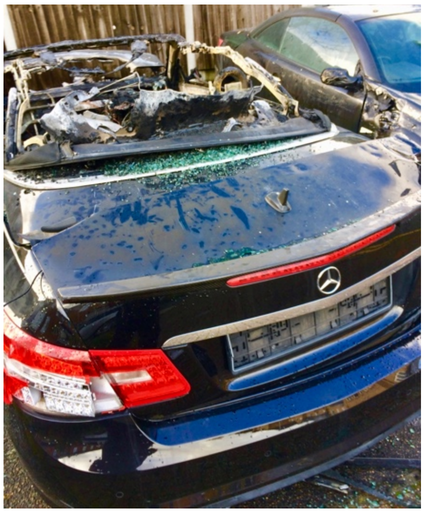
The decision to **remove 'No Ball Game' signs** has been taken by the Borough of Haringey (Haringey 2016), another London Borough confronted with significant overweight and obesity among its child population. This restriction of children's collective activity is particularly concerning around large apartment blocks or housing estates where many children live and are currently ruled out of the public space. Whilst not at all radical, removing these signs and actively making public spaces accessible and usable by children for physical activity purposes might result in a return of those children to the streets. Their presence currently leads to children internalizing a fear of damaging cars and other material property, especially when playing football – clearly a favourite game of both boys and girls in Newham.



Photos: Spaces excluding children from the public realm, by Author, 2018

REMNANTS OF CRIMINAL ACTIVITY

Remnants of knife crime, antisocial behaviour and other criminal offences could be seen throughout the go-along interviews. Smouldering cars or other motorized vehicles, destroyed bins that were set on fire, waste resulting from drug and alcohol use, and graffiti were some of the daily reminders for children in Newham that personal safety in the Borough is not always guaranteed. This frequently instilled a justified sense of anxiety among interviewees. In academic literature, ample reference is made to 'stranger danger', described as a moral panic among parents and children resulting from fears concerning personal safety of the child in the public space.



However, the figures on knife crime and the remnants of antisocial behaviour observed in Newham demonstrate that these concerns are not irrational or overstated, but the result of a difficult reality. The ward of Stratford & New Town in the Borough had the highest volume of knife crime in London in the financial year 2017/18, and Newham had the third-highest volume of any London Borough over those twelve months (MOPAC 2018). Knife **crime is a real and serious concern** in Newham, as it is across London, sadly also involving minors both as perpetrators and victims. London authorities strive to reduce the risk and number of knife crime incidents (Mayor of London 2017). Nonetheless, whilst this initiative is laudable, until incident rates drop, children in London are still exposed to the real threat posed by knife crime.

Photo: Remnants of criminal activity can be seen across the Borough, by Author, 2018

> *"He didn't wake up, so he died. And there's spray paint of [boy's name] on the wall. So every time you pass you see where he died."*
>
> **– Interviewed girl aged 10**

Photo: A crime scene in Newham. bv Author. 2018

Nearly all interviewed children brought up personal safety as a concern when playing in the public space and crossing the Borough's streets and alleyways. Multiple pupils were able to point out crime scenes on the way to or from school. Moreover, several participants were acquainted with a victim of knife crime in Newham, **inspiring fear** and causing them and their parents to be cautious about spending time outdoors or leading to the decision to refrain from actively commuting to school. Our findings also support the earlier observation that UK parents fear being judged by other members of the public if they allow their children to play and be outside unsupervised (Community Practitioner 2013), resulting in a culture of parenting that counteracts an active lifestyle. Knife and other crime does thereby not only cause anxiety among Newham residents, it also has a profound health impact through a reduction in children's physical activity levels.

THE FOOD ENVIRONMENT AROUND SCHOOLS

Earlier research on the impact of the local food environment on children's diet in East London, including in Newham, has shown a significant relation between the number and proximity of takeaways and convenience stores on the food choices of adolescents (Smith et al. 2013). During the interviews, actively commuting children in our Newham sample regularly hopped into the convenience stores that lined the streets along their commuting routes or described frequently visiting takeaways on the way home in order to provide dinner, particularly 'chicken & chips' shops. Upon further questioning, the food choices made in these outlets consisted primarily of highly calorific or high-fat snacks that were perceived as a reward by parents and children. These **poor dietary choices** are **not always balanced by** the provision of **healthy food options** in the Borough, thereby limiting the possibility for parents and children to consume healthier food items. This is particularly problematic, as it is the group of healthy, actively commuting children who are particularly exposed to this intrusive presence of unhealthy dietary items in those 'food deserts'. In a car-dominated public space with strongly centralized services, shops and food outlets are often some of the few places residents can walk to. Streets lined with takeaways and convenience stores then become true calorie pathways, where children and adults alike are incited to consume unhealthy food items. Hence, the interviews demonstrated the clear need to support the Mayoral initiative to ensure healthy food environments, especially around schools (GLA 2017).

Photo: Convenience stores lining the commuting roads in close proximity to a Newham school, by Author, 2018

AIRPLANE NOISE

Children regularly highlighted the negative **impact of airplane noise on their school performance and** the disruption it causes to their **outdoor conversations and activities.** London City Airport, located in the South of the Borough, is opened between 6.30am and 10.30pm on weekdays, and half days on weekends. The airport's noise action plan shows that a significant number of households and public institutions, including schools, are located in the geographic area where the noise exceeds the weighted equivalent sound pressure level of 54 decibels (dB) for sixteen hours per day, which is the level at which *"significant community annoyance occurs"* (London City Airport 2018, p. 31).

This is below the 63dB threshold above which the government expects airport operators to financially contribute to the insulation of noise-sensitive institutional buildings such as schools and hospitals. It is therefore unsurprising that children referred to their teachers having to interrupt class or raise their voice in order to make themselves understandable. Moreover, children, especially those residing just south of London City Airport in the Royal Docks, Silvertown and North Woolwich, blamed airplane noise for the interruption of their play and conversations while commuting, causing significant irritation.

> *"The **airplanes** are annoying, because in school, they **keep interrupting the lesson.** Because they're noisy. [...] When the airplanes pass, our teacher, he has to speak in a low voice and it's annoying."*
>
> *"My brother is trying to **talk to me, and he'll stop, because the aeroplane**. And then after I'll tell him to carry on but he forgot what he was saying."*
>
> **– Interviewed girls aged 9 and 10, living west and north of London City Airport**

Photo: An airplane taking off from London City Airport, by Author, 2018

BUILT ENVIRONMENTAL STIMULI OF PHYSICAL ACTIVITY

PHYSICAL CHALLENGES FOR CHILDREN WALKING TO SCHOOL

Children walking to school in Newham indulged in the **physical challenges** provided by the built environment along the way. They climbed steps, walked on the narrow walls that surround flower beds, jumped from one large paving stone to another or sprinted across squares and open spaces. This often went hand in hand with an intense focus, whereby children seemed to be lost in their thoughts, temporarily disengaging with the interview and paying attention only to the challenge they had taken on. Moreover, children doing this were often imaginative, making noises and gestures, seemingly pretending to be not simply a child walking to or from school, but a superhero or athlete.

In engaging with their built environments in this way, children choose to take a certain amount of **risk** and dare themselves to overcome structural hurdles in their neighbourhood that require significant physical skill. It also briefly allows them to act **independent of their accompanying adult**, making decisions about how to use their body to deal with a physical obstacle. These environmental challenges thereby result in many benefits for the child: higher physical activity, independent decision making, and the significant development of motor skills. These observations match the literature on parkour (Gilchrist & Wheaton 2011). Parkour is a form of 'lifestyle sport', whereby an individual moves through predominantly urban environments in a fluid manner, overcoming various human-made or natural obstacles. Whilst for youth and adults engaging in parkour is often a conscious choice, the interviewed children in Newham seem to be intrinsically drawn to these obstacles. Given its many benefits, the construction of such **urban parkour** along commuting routes for children on the way to and from school **should be stimulated**.

Photo: Children like to jump down steps and walk on narrow walls surrounding flower beds, by Author, 2018

THE PROVISION OF RECREATION FACILITIES

Children included in the study generally expressed their **happiness about** a number of **recreation opportunities** that were available to them. Modern, **diverse and well-maintained** playgrounds such as the Keir Hardie and Canning Town recreation grounds were particularly popular and frequently cited as examples to follow. These facilities have a wide diversity of excellent recreation provisions for children of all ages, allowing them to challenge themselves, share the experience of free play and sports with other children, or discover the natural environment. Monkey bars, climbing frames, slides and swings were particularly popular, as were cycling opportunities. Parents can be active in those areas as well, and they are generally well-looked after, with plenty of trees providing a spacious feel and being aesthetically pleasing. Looking beyond play opportunities, Newham City Farm is a particularly good example of a recreation facility that attracts children's attention and incites their active commuting around school times and on weekends. Importantly, children also expressed feeling safe when using these facilities. Promoting the use and awareness about the freely available recreation opportunities is therefore vital.

However, other facilities that do not have those characteristics are often far less appreciated, resulting in children travelling long distances to other, more attractive recreation opportunities, frequently by car. Examples of such less-appreciated places include Beckton District Park South and Cundy Park. The importance of greenspace, a wide diversity of play elements, physical challenges, the limited presence of unleashed, scary dogs, and meticulous maintenance is recognized in the literature (Shackell et al. 2008), and the success of the **good examples** in Newham **should be replicated** across the Borough. This is especially important in close proximity to schools, as attractive recreation facilities can incite extracurricular play and sports engagement after school or during the commute home.

Photos: Attractive and less so - the Keir Hardie and Beckton District Park South playgrounds, by Author, 2018

The interviewees also highlighted the importance of **indoor play facilities**, and in particular Newham Leisure Centre, providing the opportunity to be physically active throughout the year. In case of rain and cold weather, engaging in sports under controlled climatic conditions is vital for children to ensure they have the possibility to meet activity targets.

The swimming pool in the leisure centre was particularly popular, not only as a place to have fun and be active, but also as a social actor, constituting a place to meet friends and family. Moreover, as **swimming** does not require extensive training or expensive equipment and is usually supervised, it has a low engagement threshold. Expanding the capacity and number of Leisure Centres and ensuring they are easily accessible to all children – both in terms of transport and finance – is therefore key to maximizing their potential positive effect on children's activity and health.

PEDESTRIAN-ONLY ALLEYWAYS

A short distance to school is crucial in stimulating the choice for active modes of commuting, as primary schoolchildren living within one mile from school are more likely to choose for active modes of travel if there are no significant barriers (D'Haese et al. 2011). Aside from supporting the planning of schools in residential areas with a large share of children, this observation points to a **unique strength of the Newham built environment** that has the potential to incite walking or cycling to school: the widespread presence of **pedestrian-only alleyways** that cut through the Borough and **allow for quick commutes** on foot or by bicycle to various places and services in the area.

Children often experience a certain fear of claustrophobic, dark pathways where they feel out of sight (Williams et al. 2005). Moreover, an abundance of litter and remnants of antisocial behaviour can be found in the alleyways. Many of the children in our sample shared their concerns about these nuisances, however, they were often also very happy about the traffic safety provided by the alleyways as there were no speeding cars, and the presence of an adult accompanying them on the way to school was reassuring. **Bolstering this potential** of alleyways in Newham to stimulate walking and cycling among schoolchildren is therefore **crucial**, and will depend on the Borough's efforts to keep them clean, well-lit, safe and spacious where possible.

Photos: Alleyways can be activity drivers, but need to be clean, well-lit and safe, by Author, 2018

> *"There was an incident when I was younger and I nearly got snatched, but I managed to run away. Like, there's streets and corners and little alleyways, and that's why we don't want him coming back on his own. It gets dark quickly in winter like now as well."*
>
> **– Sister of interviewed boy aged 9, on the importance of safe and well-lit alleyways**

ACCELEROMETER AND ACTIVITY DIARY DATA

The children's narratives provide a gripping insight into the daily neighbourhood experience of Newham schoolchildren, and were complemented by information from accelerometry and activity diaries to obtain an insight into their objective activity patterns. As Figure 5 shows, only 13.6% of Newham children included in our sample met the minimum requirement of 60 minutes of moderate-to-vigorous activity every day (WHO 2019). On average, the image is slightly more positive. However, still only 40.9% of children accumulated 420 minutes of moderate-to-vigorous activity in one week, equivalent to the one-hour daily target. Yet, at 45.5%, the **proportion of children not meeting average activity requirements** is still **larger**.

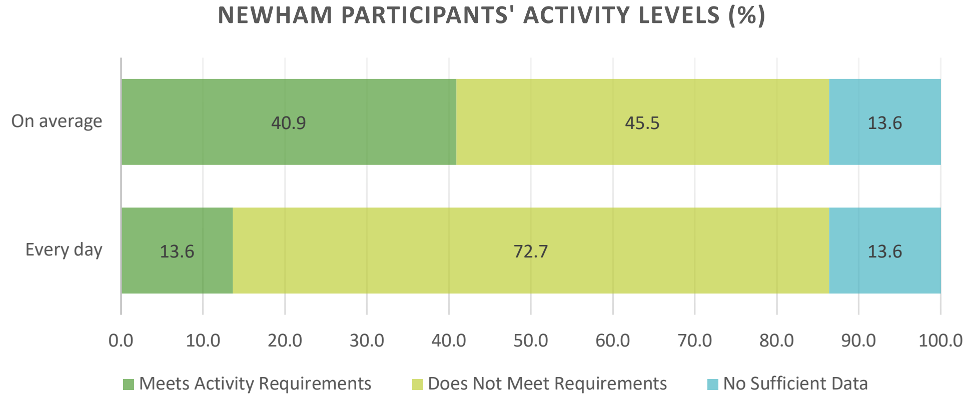
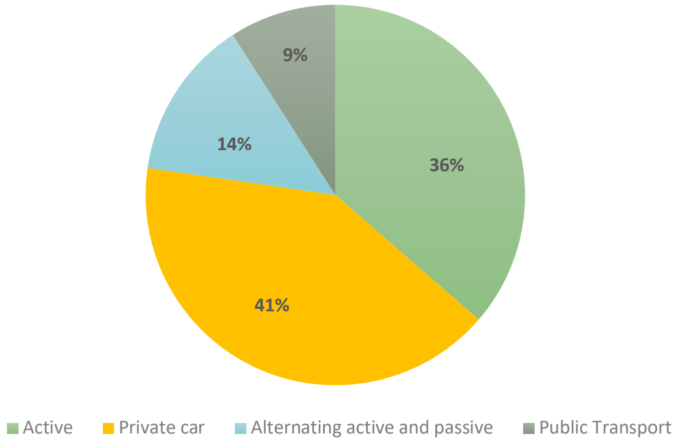


Figure 5: Activity levels for interviewed children in Newham, percentage meeting 60 minutes of moderate-to-vigorous activity based on strict WHO criteria and on average

Figure 6 shows that only 36% of interviewed children predominantly walked, cycled or scootered to and from school during the week following their interview, whereas over 40% mainly used the car. A quarter of those passive commuters lived within the walkable distance of one mile. The need to address built environmental barriers to achieve an increase in children's physical activity is thus clear and urgent. **Stimulating active commuting** is one particularly promising pathway in that respect, especially through its links with lower obesity levels (Bosch et al. 2019).

These low levels of physical activity become even more striking upon noting that children collected **most** of their **activity on weekdays,** and particularly **during school hours**. On a school day, over half of children's activity (56.2%) took place between the start and end of school. The school thus seems to play a crucial role, not only in providing education, but also in stimulating children's activity. Children were also less active on the weekend. The Newham schoolchildren in our study collected an average of 72.8 minutes of moderate-to-vigorous activity on a regular school day, versus only 46.6 minutes on an average Saturday or Sunday. This implies that, with the right neighbourhood incentives, **significantly more extracurricular activity can be gained**. This will allow more children to meet minimum activity requirements.

Figure 6: Dominant mode of commuting for interviewed children in Newham



POLICY RECOMMENDATIONS FOR NEWHAM COUNCIL & SCHOOLS

The interviews resulted in the collection of a diverse set of inspiring and grounded accounts of children's everyday life in the Newham built environment. Children view their surroundings differently from adults, often interacting more closely with it, and experiencing barriers and stimuli grown-ups don't notice (Gascon et al. 2016). Throughout the research, participating pupils proved capable of building a coherent argument, elaborating carefully on the benefits or downsides of environmental aspects, and often suggesting creative yet realistic solutions to address challenges and bolster strengths. Therefore, to make future urban design and policy development in Newham truly inclusive, the **installation of a Newham children's panel** is strongly encouraged. This guarantees their voice is directly accounted for in the Boroughs' policymaking, and actively recognizes them as key constituents of local communities.

For Newham Borough Council and schools, the built environmental barriers and stimuli described by the interviewed children provide a strong impetus for the implementation of policies that stimulate their choice for active commuting to school and engagement in outdoor, extracurricular sports. Managing child activity and weight status is not the sole responsibility of parents, and the Borough has a crucial role to play in inciting physical activity and reducing the overweight and obesity epidemic through the built environment. Therefore, **for each of the built environmental obstacles and drivers, two policy recommendations** were designed that could significantly contribute to inciting higher activity levels among primary schoolchildren in the Borough. This results in an 18-point policy plan for the Borough Council and schools to address the flaws and harness the strengths of Newham's built environment.

TACKLING BUILT ENVIRONMENTAL BARRIERS TO PHYSICAL ACTIVITY

NEIGHBOURHOOD CLEANLINESS (RECOMMENDATIONS 1 & 2)

- Increase Council efforts to ensure the public space is kept free of litter and dog or drug waste by employing **sufficient staff in charge of neighbourhood cleanliness**. Importantly, garbage collection should not coincide with the morning or afternoon commute of schoolchildren, as this might deter active commuting.

- **Actively patrol** for dog waste, litter and fly-tipping, and fine perpetrators. Ensuring neighbourhood cleanliness is a joint responsibility, hence, the reporting of antisocial behaviour should be encouraged and quickly acted upon. Moreover, schools could organize 'cleaning-up brigades', whereby children jointly clean up the area around school, in combination with classes on the environmental impact of waste.

SEASONALITY (RECOMMENDATIONS 3 & 4)

- Provide **sufficient lighting** along busy commuting routes, alleyways and at crossings. Darkness often scares children, and might lead to a preference for passive commuting.

- Ensure children's play and **activity engagement** is possible **irrespective of the weather conditions**, both in school and in the public realm, and inform children about the need to engage in physical activity throughout the year, particularly in the outdoor. This can be done by increasing the number and capacity of well-maintained and accessible indoor leisure centres and swimming pools, and shielding outdoor facilities from rain, ice and snow by covering them with a roof structure.

SHARED PUBLIC SPACES (RECOMMENDATIONS 5 & 6)

- Maintain and **diversify public spaces**, prioritizing children over cars and not the other way around. Decrease the importance of car-dominated areas by limiting parking space, and implement elements that incite children's play, sports and active commuting, in particular cycling provisions. Also provide opportunities for members of local communities to socialize outside and supervise children. Schools can consider facilitating children's use of the public space even further by organising walking school buses and inviting bicycle doctors to resolve practical constraints children experience.

- **Remove** all **'No Ball Games' signs** across the Borough. Furthermore, to incite the active inclusion of children in the built environment, especially around dense housing estates and apartment blocks, contemplate adding 'Children welcome to play here' signs.

REMNANTS OF CRIMINAL ACTIVITY (RECOMMENDATIONS 7 & 8)

- **Immediately remove any remnants of antisocial behaviour and crime** scarring the built environment, as clean and aesthetically pleasing neighbourhoods are experienced as safer by residents and passers-by.

- Assist the efforts to **fight the knife crime epidemic** where possible, in particular in relation to youth crime. This should not only be done through strong police action: schools can also play a role by providing information to pupils and allowing them to have a conversation about their experiences and fears in the neighbourhood. This can highlight areas of concern that need urgent addressing. Ensuring that the information provided is realistic and relevant is key, as children – and by consequence their parents – might get anxious when confronted with unnecessary scare-mongering, thereby lowering their activity and impacting their health.

FOOD ENVIRONMENT AROUND SCHOOLS (RECOMMENDATIONS 9 & 10)

- **Refuse** the establishment of **new convenience stores and takeaways** within a 400 metre (0.25 mile) radius around schools, and enforce the display of healthy snacks at counters.

- Schools can consider **offering healthy snacks** to their pupils at the end of the school day, which they can consume on the way home instead of energy-dense, unhealthy food items.

AIRPLANE NOISE (RECOMMENDATIONS 11 & 12)

- Ensure the financial support for **buildings** providing important public services, as well as private residences, to be **adequately isolated** when they lie within the area where significant annoyance occurs due to airplane noise, i.e. 54dB.

- Carry out **independent assessments** of airplane noise in the southern part of Newham to ensure maximum noise levels are not breached.

HARNESSING BUILT ENVIRONMENTAL STIMULI OF PHYSICAL ACTIVITY

PHYSICAL CHALLENGES FOR CHILDREN WALKING (RECOMMENDATIONS 13 & 14)

- Implement elements of an **'urban parkour'**, such as steps, ramps and climbing frames, around schools, which can act as nudges to stimulate children's enjoyment and activity during the commute.

- Schools should **inform** pupils and parents of the **benefits of active commuting**, including strengthening social cohesion, increasing physical activity and developing navigational skills, instead of focusing on risks posed by crossing the public realm.

THE PROVISION OF RECREATION FACILITIES (RECOMMENDATIONS 15 & 16)

- Bring all public and school playgrounds and public **recreation grounds** up to the **standards** of the most popular examples across the Borough, especially in close proximity to schools where they might incite extracurricular activity. Schools can actively encourage the use of these facilities, by organising in-school PE or sports days, or out-of-school activities there, and the Borough can organize staff- or volunteer-led activities as well. This will bring children together and boost their extracurricular physical activity levels. Moreover, the capacity to include all interested children should be ensured.

- Playgrounds should be well-maintained at all times, by replacing and updating broken equipment. Moreover, a **diverse** set of play elements for children of all ages should be provided, and adult supervision and physical activity should be facilitated. Climbing frames, slides and swings proved particularly popular in that respect. Ensure greenspace is well-maintained and no litter or antisocial behaviour is tolerated, and restrict areas where dogs are allowed to roam freely without a leash.

PEDESTRIAN-ONLY ALLEYWAYS (RECOMMENDATIONS 17 & 18)

- Ensure the **safety, lighting and cleanliness** of alleyways cutting through the Boroughs, enabling children to use the shortest route to school and other destinations, thereby inciting active commuting.

- **Make sure children feel comfortable** using these pedestrian-only pathways by lowering high walls and cutting down disturbing vegetation, raising their visibility and sense of security.

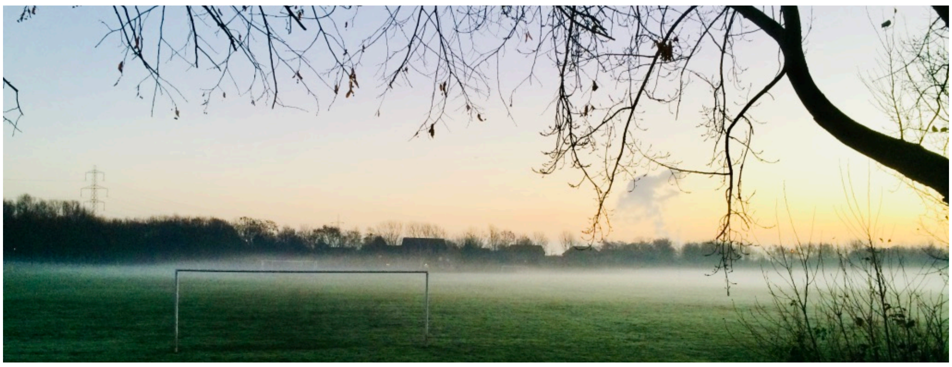


Photo: Beckton District Park's playing fields on a crisp winter morning, by Author, 2018

CONCLUSION

Seeing children walk or cycle to school and play outside used to be a common sight until a couple of decades ago. However, while the share of children growing up in cities keeps rising, their presence in the urban environment has significantly declined. Changes to the built environment in children's home and school neighbourhoods play an important role in this decline, which has resulted in a double epidemic of childhood overweight and obesity on the one hand, and children's inactivity on the other.

Based on go-along interviews with a sample of primary schoolchildren, this report assessed the strengths and weaknesses of the neighbourhood built environment of children in Newham in stimulating their outdoor physical activity. The narratives that emerged when crossing the neighbourhood with participating children paint an intense and detailed picture of their daily physical activity.

Children living in Newham grow up in a Borough where **significant barriers to** their outdoor **physical activity** exist, which should be urgently addressed. Polluted and unsafe neighbourhoods with a plethora of unhealthy food choices deter their active commuting to school and incite the choice for a highly calorific diet. The lack of shared public spaces then adds to a reduction of these children's outdoor play. Noise pollution because of airplanes interrupts their conversations and play both in- and outside.

However, whilst these challenges require immediate action, Newham can also rely on **several unique built environmental stimuli** that set the Borough apart and could potentially incite children's active commuting to school and sports engagement. The alleyways cutting through the Borough, the play facilities provided, and the physical challenges along children's walking routes can, if managed well, add significantly to their physical activity outside of school. Much progress is still to be made here, as shown by the accelerometry and activity diaries.

The **policy recommendations** for Newham Council and schools in the Borough – some more ambitious and involving many actors, other more focused and easily implementable in the short term – hold the potential to contribute significantly to the aim of **raising children's activity levels** and making the Borough, and London at large, a city where "everyone is welcome" indeed. Through the implementation of these suggested measures, physical structural prevention making the active and healthy choice the easier and default option is built into the Borough (Troelsen et al. 2013). Taking the health and wellbeing of future generations into account in urban design and planning is key, and it is hoped this report can contribute to shaping Newham into a healthy, diverse and inclusive Borough.

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